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Classification and Reduction of Pilot Error

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1.0 SUMMARY

This report documents the work done under contract NAS1-18027, task assignment 13, titled "Classification and Reduction of Pilot Error," during the period January, 1988 to February, 1989.

1.1 SCOPE

The tasks described here constitute the first year's effort of a multiyear program aimed at reducing the deleterious effects of pilot errors on aviation safety. It entailed an approximately 1.5 man-year effort and consisted of a literature review, error classification analysis, factor-error hypotheses formulation, accident and incident data review, and empirical evaluation of hypotheses.

1.2 PURPOSE

The multiyear purpose of this effort is to reduce pilot errors in the commercial flight deck. The purpose of this year's study was to (1) assess the state of the current understanding of human error events and (2) based on this understanding, develop and test selected hypotheses concerning the relationship between a specific set of underlying factors and resulting error types and frequencies.

1.3 RESULTS

The review of the literature indicated that much work in the area of human error has been done. Classification taxonomies were reviewed and that of Jens Rasmussen was selected as representing the state of the art. Description of the events, circumstances, factors, and internal mechanisms involved in human error is quite complete, while explanation is in its infancy. The taxonomy of Rasmussen was modified and tailored to operational factors and circumstances associated with pilot errors in commercial aviation. Hypotheses involving a specific set of factors were developed, and four searches of the Aviation Safety Reporting System (ASRS) incident database were requested to determine if there were incidents that substantiated the hypotheses. A piloted simulation experiment was initiated to further test these hypotheses.

1.4 WORK IN PROGRESS

The searches of the ASRS database have yet to be fully analyzed and reported. A replication of the simulation experiment is required, and analyses and report of the data are to be completed. This work is scheduled to be performed in the second year of the program.

1.5 CONCLUSIONS

An excellent foundation exists in current error classification schemes and categorizations of underlying factors for a better understanding of human error. The gap that exists is in converting general notions concerning the relationship between underlying factors and error types and frequencies into testable,

quantifiable, operational hypotheses. We believe development of specific, testable hypotheses; substantiation of these hypotheses through reports from accident and incident databases; design of empirical tests aimed at error assessment under "worst case," but face valid, combinations of factors; and finally, modification of key underlying factors to bring about error reduction, will be a very productive approach to the pilot error problem.

1.6 LIMITATIONS

The tasks described here are a very preliminary step in a systematic approach to error reduction. This approach must begin with a thorough understanding of the factors involved in human error, but in terms of the total effort required for this approach to ultimately impact aviation safety, the current study just scratches the surface.

2.0 INTRODUCTION

"Pilot error" has been cited as a contributing factor in 80% to 85% of general aviation accidents (refs. 1 and 2), in 50% of ASRS reported incidents (ref. 3), and in 60% to 65% of commercial jet accidents (refs. 4 and 5) in recent years. Consequently, while worldwide jet aircraft accident rates have been steadily decreasing and are currently very low, reduction of pilot error factors is viewed as the last frontier for substantial improvements to aviation safety. Interest in reduction of pilot error is not new. In 1947, Fitts and Jones stated: "It should be possible to eliminate a large portion of so-called 'pilot error' accidents by designing equipment in accordance with human requirements" (ref. 6).

2.1 BACKGROUND

Because the impact of human errors in aviation can be so catastrophic, efforts to reduce human errors have a long history. Avoiding errors is part of the reason behind automation, the application of human factors to cockpit design, rigorous selection criteria for pilots, and standardized operating and training procedures. Efforts in error reduction continue. Cockpit design and operating procedures are continually improving, and crews are becoming aware of the kinds of errors that can occur in the flight deck through programs such as cockpit resource management. While strides have been made in reducing the probability of some kinds of pilot error, some error types as old as aviation itself continue to haunt us. As the aviation environment and aircraft systems become more complex and automated, there is an opportunity for new error types to emerge (ref. 7). Reasons for this limited progress in reducing pilot error are many-fold: the lack of a true understanding of the underlying causes, their interrelationships and interactions; the lack of a total systems approach to pilot error reduction; and the absence of a comprehensive theory or model of pilot error, are just a few. Part of the problem has been the vague "umbrella" definition of the term pilot error; in a sense pilot error "can explain everything and nothing about aircraft accidents and incidents" (ref. 8).

Pilot error implies a lack of competence on the part of the pilot, but in fact describes a class of complex, multidimensional circumstances that contribute to accidents and incidents, with the common denominator being pilot involvement. Commonly cited pilot errors include reversal or omission of steps in a standard procedure, selection of an inappropriate control setting, poor judgment or decision making, and miscommunication, each describing an event that includes its own set of circumstances, with each circumstance including its own set of causes. Further, pilot error often involves a chain of events, i.e., pilot error cannot be understood as a static set of circumstances.

It is important to distinguish between two kinds of errors—those that are systematic (i.e., there is an identifiable set of factors to which the error can be attributed) and those that are random (i.e., the occurrence of the error has no pattern of preceding and accompanying factors or at least that pattern has not been discovered yet). This distinction underlies two approaches to eliminating the negative consequences of pilot error:

1. **Error reduction.** Through an understanding of the factors underlying systematic pilot errors, those errors can be reduced in frequency by changing the underlying factors, such as flight deck design and operating or training procedures.

2. **Error tolerance.** Those errors that cannot be predicted (random errors) and those that might have positive consequences (i.e., serve some adaptive purpose) can be tolerated if systems are designed to detect, alert, warn, and protect against the negative consequences of these errors. The primary means of accomplishing error tolerance has historically been redundancy (of systems and humans), but recent advances in artificial intelligence and the general sophistication of system and human monitoring capabilities make automated error tolerance one of the most promising ways of reducing the negative consequences of crew error in the future.

2.2 PROGRAM GOALS AND OBJECTIVES

This program is concerned with error reduction. The multiyear goal of this effort is to reduce the probability of crew errors by modifying contributing factors. The multiyear objectives, which will aid in achieving this goal, are—

1. Identify and organize the heterogeneous set of circumstances that constitute a pilot error event.

   a. Identifying, defining, and categorizing the operational factors that underlie errors, such as design, workload, and procedures.
   b. Identifying the internal mental processes, such as memory, attention, and judgment, the failure of which results in human error.
   c. Distinguishing among different error types.

2. Evaluate the relationships among the factors, mechanisms, and errors. This process will form a sound foundation for efforts to predict and, ultimately, reduce pilot error.

3. Develop and test hypotheses concerning the error-reducing effect of modifications to underlying factors.

A series of subtasks was performed as part of the 1988 contract effort to help achieve the first two multiyear objectives. This series includes the following tasks:

1. Review of the literature.
2. Development of a comprehensive classification scheme.
3. Development of specific factor-error hypotheses.
4. Analytical evaluation of hypotheses.
5. Empirical evaluation of hypotheses.

These tasks are described in the following sections.

3.0 LITERATURE REVIEW

The review of the literature and development of a computerized database of human error references was the first task initiated under this contract. There has been a great deal of work in human error, crew error, and related topics. Our strategy was to assess the theoretical state of the art as well as the operational. One of our working assumptions is that a conceptual understanding of the factors and internal mechanisms underlying human error is essential to systematic reduction of errors. The literature review allowed us to base our effort on the foundation of expertise in human error that already exists.

3.1 OPERATIONAL LITERATURE

Literature reviewed included work related to safety and human error issues from many operational environments, including primarily industries such as aviation (refs. 6, 9, 10, and 11) and nuclear power (refs. 12 and 13). It is not surprising that industries in which human errors have readily observable and catastrophic effects are at the forefront of work on human error.

In terms of identifying all the factors that contribute to error events, particularly in the aviation environment, some of the aviation accident and incident investigation and reporting manuals were the most comprehensive. The National Transportation Safety Board (NTSB), the International Civil Aviation Organization (ICAO), the Aviation Safety Reporting System (ASRS), and others have detailed compilations of factors for investigators and reporters to check in an accident or incident investigation. The ICAO Accident/Incident Reporting Manual (ref. 14), for example, lists 9 categories of more than 100 underlying factors, which they label explanatory factors (e.g., see table 3-1), that can contribute to the human error cause of an accident or incident. Each of these factors can be associated with one or more modifiers, from a list of about 100. Although these factor lists do not relate factors to internal mechanisms or error types as will be discussed in the review of some of the theoretical error classification schemes below, they are extremely thorough in what they were intended to do: identify and categorize factors that could contribute to a human error that results in an aviation accident or incident. Appendix 1 provides a comprehensive listing of factor categories found in the literature. Each category includes a listing of the associated factors and the reference(s) that use that category. The accident and incident manuals discussed above were the major source of this compilation.

3.2 THEORETICAL LITERATURE

Other articles reviewed were more theoretically oriented, describing or explaining generic human errors in terms of the relationship between factors, internal mechanisms, and different types of errors (refs. 15, 16, and 17). Norman (ref. 15), for example, described the distinction between mistakes (i.e., an error based on an inappropriate intention) and slips (i.e., performance of an action that was not what was intended). He divided slips into three categories (each with subcategories): errors in the formation of intentions, faulty activation of schemas, and faulty triggering. These different types of slips are hypothesized to occur as a result of different external factors and information processes, and thus it is important in any effort to reduce errors to know the type of errors that are being addressed. Rouse and Rouse (ref.

Table 3-1. Factors Developed by ICAO for Accident and Incident Investigations

Explanatory factors Subjects		Explanatory factors Subjects		Explanatory factors Subjects	
Code	Text	Code	Text	Code	Text
9900 00	Physiological factors	9910 33	Skill	9940 00	Management
9900 06	Fatigue – chronic	9910 36	Training – initial	9940 01	Approval
9900 09	Fatigue – time zone	9910 39	Training – on the job	9940 03	Budgeting
9900 12	Fatigue – work schedule	9910 42	Training – ground	9940 06	Compliance
9900 15	Fatigue – other	9910 45	Training – flight	9940 09	Coordination
9900 18	Circadian rhythm	9910 48	Training – recurrent	9940 12	Decisions
9900 21	Diet	9910 51	Qualification – position	9940 15	Directives
9900 24	Drugs	9910 54	Qualification – on type	9940 18	Instructions
9900 27	Alcohol			9940 21	Forecast
9900 30	Carbon monoxide	9920 00	Communication	9940 24	Funding
9900 33	Hangover	9920 03	Interpretation	9940 27	Inspections
9900 36	Heavy smoker	9920 06	Phraseology	9940 30	Liaison
9900 39	Heart attack	9920 09	Language barrier	9940 33	Monitoring
9900 42	Preexisting medical condition	9920 12	Noise interference	9940 36	Observation
9900 45	Motion sickness	9925 00	Psychological condition	9940 39	Orders
9900 48	Unconsciousness	9925 06	Anxiety	9940 42	Organizing
9900 51	Decompression sickness	9925 09	Apprehension	9940 45	Personnel
9900 54	Disorientation/vertigo	9925 12	Attention	9940 48	Planning
9900 57	Visual illusions	9925 15	Attention span	9940 51	Policy
9900 60	Hypoxia/anoxia	9925 21	Inattention	9940 54	Procedures
9900 63	Hyperventilation	9925 24	Boredom	9940 57	Quality control
9900 66	Previous diving	9925 27	Distraction	9940 60	Recruitment
9900 69	Acceleration	9925 30	Coordination/timing	9940 63	Regulations
9900 72	Effect of vibration	9925 33	Confidence – in A/C	9940 69	Requirements
9900 75	Effect of glare	9925 36	Confidence – in equipment	9940 72	Resource management
9900 78	Effect of heat	9925 39	Confidence – self	9940 75	Specifications
9900 81	Effect of cold	9925 42	Complacency	9940 78	Staffing
9900 84	Effect of windblast	9925 45	Emotions	9940 81	Standards
9900 87	Effect of noise	9925 48	Mental capacity	9940 84	Training
9900 90	Effect of toxic fumes	9925 51	Mental pressure – external	9940 87	Supervision
9900 93	Vision	9925 54	Mental pressure – self induced	9940 90	Work environment
9900 96	Other	9925 57	Panic	9945 00	Design Factors
9905 00	Supervisory factors	9925 60	Perception	9945 03	Instrument/controls design
9905 03	Briefing	9925 63	Task saturation	9945 06	Instrument/controls location
9905 06	Crew coordination	9925 66	Reactions	9945 09	Workplace design
9905 09	Monitoring	9935 00	Psycho-social factors	9945 12	Structures
9905 12	Supervision	9935 03	Attitude	9945 15	Systems
9905 15	Other	9935 06	Industrial action	9950 00	Miscellaneous
9910 00	Experience/training	9935 09	Interpersonal relationship	9950 03	Action
9910 03	Knowledge	9935 12	Seniority	9950 06	Airmanship
9910 06	Competition	9935 15	Motivation	9950 09	Planning
9910 09	Experience – in position	9935 18	Morale	9950 12	Planning – preflight
9910 12	Experience – on A/C type			9950 18	Activities
9910 15	Experience – total A/C			9950 21	Certification
9910 18	Experience – other			9950 24	Equipment
9910 21	Recency – in position			9950 27	Facilities
9910 24	Recency – on instruments			9950 30	Manuals
9910 27	Recency – on type			9950 33	Medical certificate
9910 30	Recency – on aerodrome/ route			9950 36	License rating
9910 31	Recency – other			9950 39	Publications

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16) detailed particular characteristics of erroneous decision or actions that can occur in terms of general categories of behavioral processes (i.e., categories such as observation and choice of hypotheses). These categories and descriptions of what can go wrong at each stage is shown in table 3-2 (from ref. 16). Many other articles reviewed (see app. 1 and 2) developed classification schemes, which vary in their approach. Rouse and Rouse (ref. 16) have broadly categorized different classification schemes as being behavior oriented, task oriented, or system oriented. We are concerned here with behavior-oriented approaches that emphasize basic human information processing, because it is at this level that general principles might be derived. However, these principles must be applied to a particular operational environment, and the task-oriented and system-oriented classification schemes will provide an essential link for successful migration of the general principles to solving real world problems.

As will be discussed in section 4, Rasmussen (ref. 17) has done the most extensive work in the area of error taxonomies. He has also developed hypotheses concerning the effects of specific factors on the type of malfunction and errors that might result. For example, table 3-3 (from ref. 17) shows Rasmussen's hypotheses concerning the effects of different types of behavior (e.g., skill based, rule based, and knowledge based) on the mental functions that might be involved in an human error.

3.3 CONCLUSIONS AND PRODUCTS OF THE LITERATURE REVIEW

The primary thrust of the review of the literature was to determine what underlying factors were considered important in human error and what the relationships were among different categories of underlying factors and between those categories and different kinds of errors. Many of the articles reviewed proposed some kind of classification scheme, presenting at least in part, a structure for organizing the factors underlying error and factor-error relationships. Our goal was to use these schemes, in the aggregate, to develop a comprehensive classification scheme of the factors underlying human error, particularly as relevant to crews in commercial aircraft.

In the process of reviewing the literature, we developed a computerized database of all the reviewed references, which can be retrieved by author. The database is maintained on R:Base System V version 1.1 for the IBM PC and contains about 180 articles (the complete list of references included in the database is provided as app. 2). Future enhancement is planned to allow retrieval by key words. The key words will be the labels of the categories of the classification structure we have developed on which each reference focuses. For example, a study that addresses the effects of circadian rhythms and work-rest cycles would be given the key word "fatigue," because that is the label of the category in our scheme that covers those kinds of factors.

It became evident early in the review of the literature that it would be helpful to define many of the terms associated with human error, because the way they are defined can often be domain specific and can conflict with common usage. Consequently, as we reviewed articles, we compiled a glossary of terms relevant to human error and aviation. The glossary is broad based and is essentially an expansion of the G-10 Glossary of Terms for Human Practitioners in Aviation. This glossary has been released as Boeing document D6-54686 and is available on request. A portion of this glossary (the terms not included in the G-10 glossary) is included as appendix 3.

Table 3-2. Behavioral Categories and Descriptors for Rouse and Rouse Classification Scheme

Proposed Human Error Classification Scheme

General category	Specific category
1. Observation of system state	a. Excessive b. Misinterpreted c. Incorrect d. Incomplete e. Inappropriate f. Lack
2. Choice of hypothesis	a. Inconsistent with observations b. Consistent, but very unlikely c. Consistent, but very costly d. Functionally irrelevant
3. Testing of hypothesis	a. Incomplete b. False acceptance of wrong hypothesis c. False rejection of correct hypothesis d. Lack
4. Choice of goal	a. Incomplete b. Incorrect c. Unnecessary d. Lack
5. Choice of procedure	a. Incomplete b. Incorrect c. Unnecessary d. Lack
6. Execution of procedure	a. Step omitted b. Step repeated c. Step added d. Steps out of sequence e. Inappropriate timing f. Incorrect discrete position g. Incorrect continuous range h. Incomplete i. Unrelated inappropriate action

Definitions of Specific Human Error Categories

Specific category	Brief definition
1a. Excessive	Improper rechecking of correct readings of appropriate state variables
1b. Misinterpreted	Erroneous interpretation of correct readings of appropriate state variables
1c. Incorrect	Incorrect readings of appropriate state variables
1d. Incomplete	Failure to observe sufficient number of appropriate state variables
1e Inappropriate	Observation of inappropriate state variables
1f. Lack	Failure to observe any state variables
2a. Inconsistent	Could not cause particular values of state variables observed
2b. Unlikely	Could cause values observed, but much more likely causes should be considered first
2c. Costly	Could cause values observed, but very costly (in time or money) place to start
2d. Irrelevant	Does not functionally relate to state variables observed
3a. Incomplete	Stopped before reaching conclusion
3b. Acceptance	Reached wrong conclusion
3c. Rejection	Considered and discarded correct conclusion
3d. Lack	Hypotheses not tested
4a. Incomplete	Insufficient specification of goal
4b. Incorrect	Choice of counterproductive goal
4c. Unnecessary	Choice of nonproductive goal
4d. Lack	Goal not chosen
5a. Incomplete	Choice would not fully achieve goal
5b. Incorrect	Choice would achieve incorrect goal
5c. Unnecessary	Choice unnecessary for achieving goal
5d. Lack	Procedure not chosen
6a. Omitted	Required step omitted
6b. Repeated	Unnecessary repetition of required step
6c. Added	Unnecessary step added
6d. Sequence	Required steps executed in wrong order
6e. Timing	Step executed too early or too late
6f. Discrete	Discrete control in wrong position
6g. Continuous	Continuous control in unacceptable range
6h. Incomplete	Stopped before procedure complete
6i. Unrelated	Unrelated inappropriate step executed

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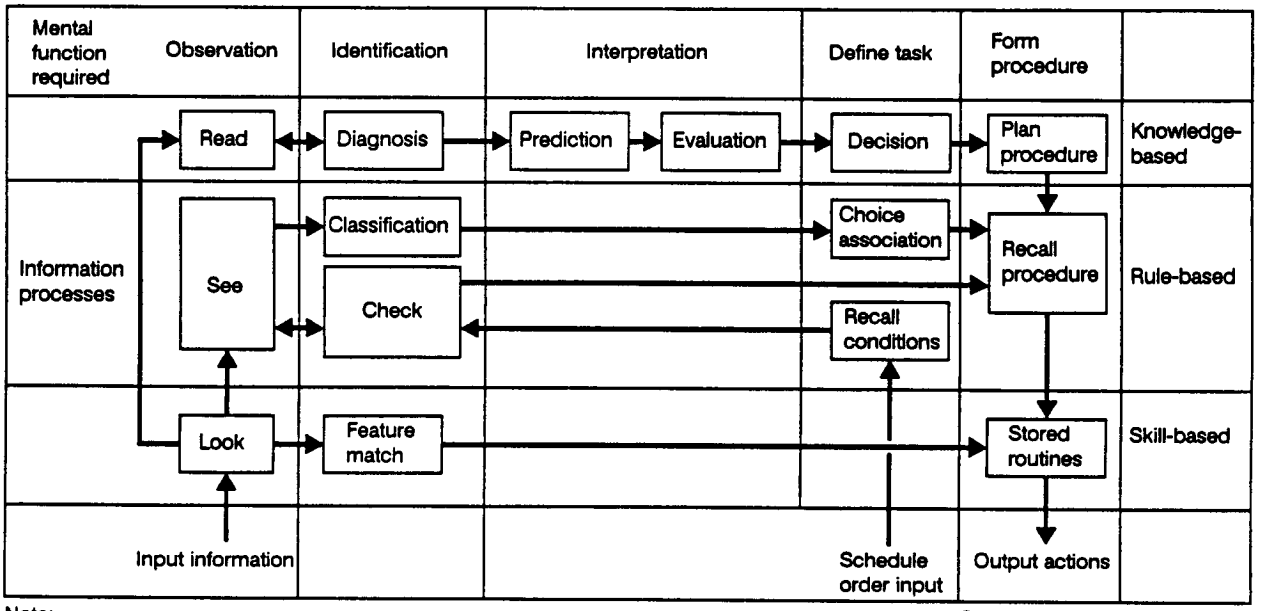
Table 3-3. Rasmussen's Behavior-Based Mental Function–Error Classification Scheme



Note:
The diagram illustrates how the same required mental function can be served by different information processes–each with particular error mechanisms.

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4.0 DEVELOPMENT OF AN ERROR CLASSIFICATION SCHEME

4.1 STRATEGY

The strategy for development of an error classification was to select one or more primary schemes from the literature that—

1. Represented current thinking in the field as to the relationships of underlying factors, human processes and attributes, and error events and circumstances.

2. Provided the most comprehensive structure in terms of inclusion of all the categories and factors involved in the human error process.

The intent was to integrate and expand existing schemes to develop the best and most comprehensive scheme possible with relevance to the aviation environment and pilot error. Many studies reviewed provided descriptive classification schemes (i.e., they enumerated and categorized the operational circumstances that contribute to error). Others were explanatory (i.e., they hypothesized why errors occur in terms of human information processing malfunctions and causal factors). Of the literature reviewed, the error classification taxonomy described in the work of Rasmussen (refs. 17, 18, and 19) was selected because it was the most comprehensive, presented explanatory as well as descriptive details, and provided a general structure to which one could add details specific to a particular domain or environment.

4.2 RASMUSSEN'S CLASSIFICATION SCHEME

A summary of the Rasmussen classification scheme is shown in figure 4-1. Rasmussen has developed seven different categories of factors relevant to human error, depicted by the boxes in the figure. The two bottom right boxes involve factors that describe what error occurred, either in terms of the external events or consequences (e.g., failed to set flaps) or in terms of the human process or action that malfunctioned (e.g., forgot a checklist item or failed to attend to checklist item). The box above these boxes describes who was involved (e.g., an operator, a maintenance person, or a dispatcher). The larger bottom box describes what went wrong (i.e., what underlying human mental or physical process

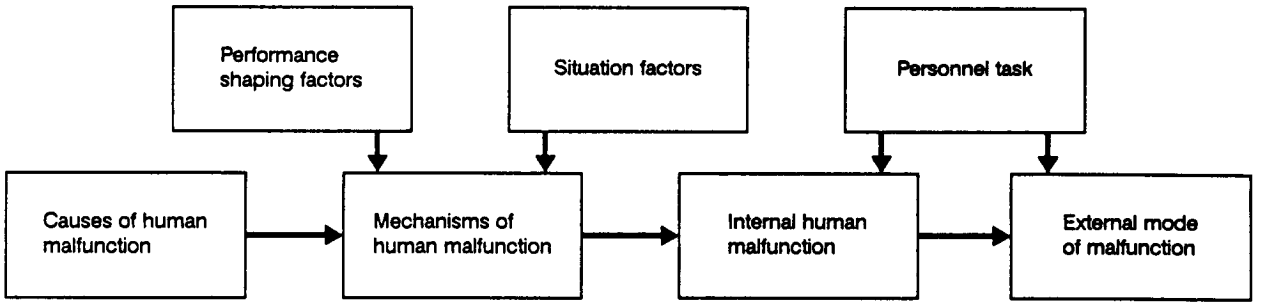

Figure 4-1. Rasmussen's Human Error Classification

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malfunctioned and how it malfunctioned). For example, the information processing step of remembering the sequence of items for a particular checklist might have failed due to competing memory demands.

Finally, the remaining three boxes describe why some human information process malfunctioned (i.e., what the underlying causal and contributing factors are). The "causes of human malfunction" category describes factors that directly cause a process to go astray, such as task demands beyond the human's capability, equipment malfunctions or misinformation that induces a human error, or a nonnormal cockpit distraction that diverts the pilot's attention. The "operator factors" (which Rasmussen labeled "performance shaping factors") and "situation factors" categories can overlap with the "causes of human malfunction," but the main distinction is the directness of their effects. The "operator factors" and "situation factors" can be thought of as contributory, because any single factor should not lead to information processing failure, but the combination of factors could provide a situation that is conducive to a certain kind of human malfunction. For example, a high level of personal stress combined with bad weather in a busy terminal area could cause task demands to exceed the pilot's current capability, which in turn causes a mental process to malfunction.

4.3 EXPANSION OF RASMUSSEN'S SCHEME

Our classification scheme development process used the basic structure of Rasmussen's taxonomy as a foundation and then integrated categories and factors from other schemes to expand and tailor it to the commercial aviation environment. A majority of the schemes reviewed were complementary to the Rasmussen scheme: his provided a general structure of the different categories of factors, processes, and descriptions of human error, and many of the other schemes elaborated on the contents of specific components or categories. For example, as mentioned earlier, the ICAO Accident/Incident Reporting Manual (ref. 14) provides one of the more comprehensive listing and categorization of operator and situation factors associated with human errors.

Figure 4-2 shows some minor structural changes and factors we have added to Rasmussen's classification scheme, based on the integration of other schemes and on our own aviation and human factors expertise. For example, situation factors have been divided into environment, task, and aircraft factors, and the potential for interactions between factors of different categories (e.g., between situation and operator factors) is depicted by connections between these boxes. The primary expansion has been that of adding detail in terms of specific aviation items that fall into each category of contributing and causal factors underlying pilot error. Figure 4-2 depicts some of these, but appendix 1, described earlier, provides a comprehensive listing of the factors in each category. Some of these factors were discussed by Rasmussen as performance shaping factors in some of his writings and are expanded and added to here. Others were added as a result of integration of the details supplied by other schemes.

The classification scheme is not an error model or testable error theory. It is, at this point, simply descriptive. However, it should provide the framework from which to formulate and test specific hypotheses between factors mechanisms and error types and frequencies.

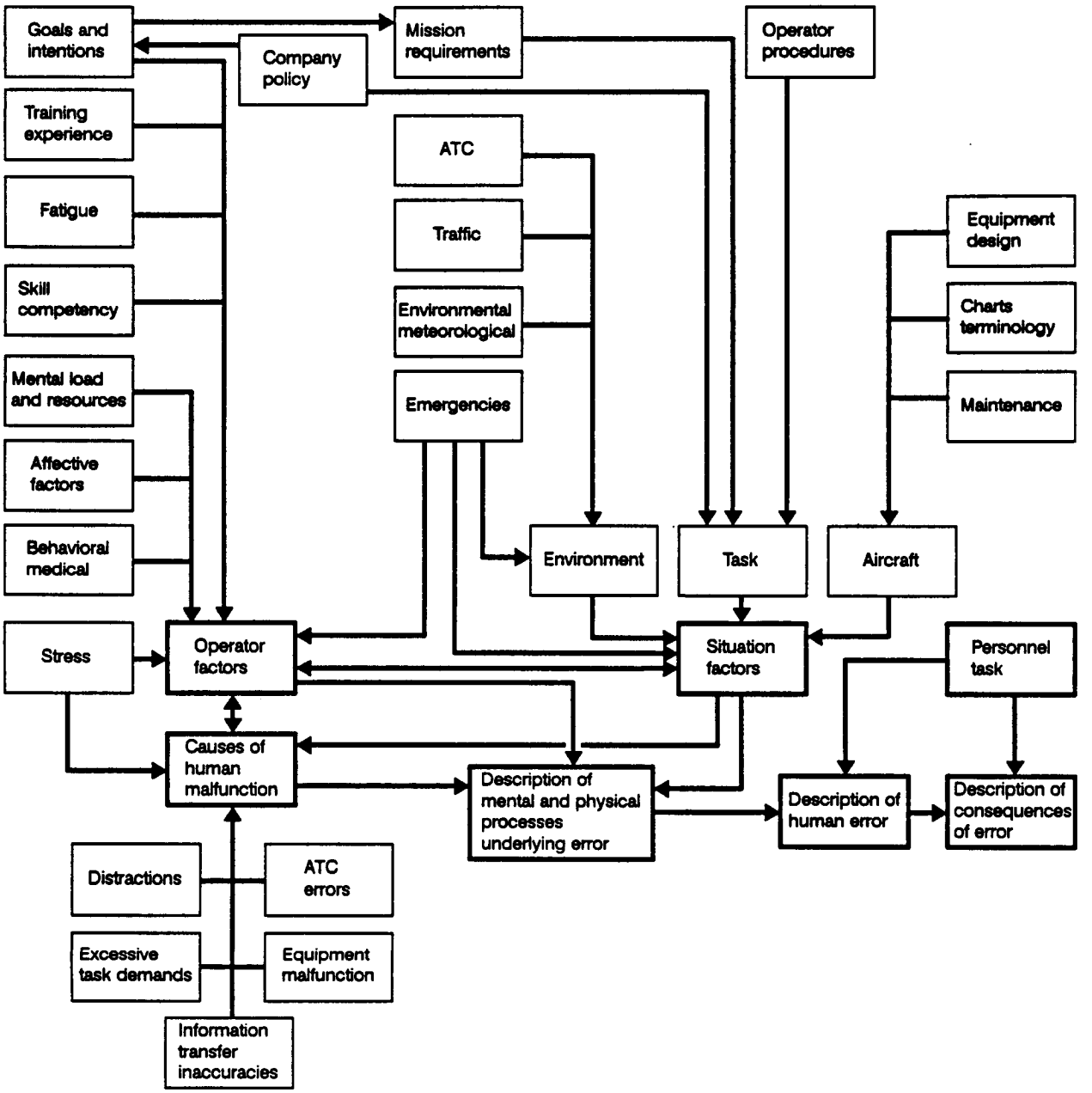

Figure 4-2. Expansion/Modification of Rasmussen's Error Classification Scheme

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5.0 DEVELOPMENT OF SPECIFIC FACTOR-ERROR HYPOTHESES

Hypotheses can be developed on the effect of combinations of factors on information processing malfunctions and resulting error types, and independently, on the effect of combinations of factors on error frequencies. Both are important and although the former is the more direct test of the general structure of the classification scheme, demonstration of the latter is more important if any error hypotheses are to be empirically verified. Empirically demonstrating operationally meaningful error frequencies as the result of any combination of realistic factors is not trivial; errors are typically not observable in the commercial flight deck environment and even if they could be observed they are made infrequently enough that the number of observations required to assess the error potential of a particular design or procedure would be impractical to achieve. In order to obtain error rates in simulation that can be meaningfully measured, a unique set of factors, which are hypothesized to lead to high probability of error and can occur in the real world but usually do not, must be selected.

5.1 SPECIFIC FACTORS SELECTED FOR EVALUATION

For the purposes of this contract, it was considered prudent to focus primarily on test of factor-error frequency hypotheses and secondarily on the more basic hypotheses concerning factor-mechanism-error type relationships. To this end, a small number of factors were selected that, in combination, were hypothesized to be problematic in terms of leading to high error rates. Where possible, the internal mechanism and error type were hypothesized as well. The factors selected had to meet the following pragmatic criteria:

1. They had to be quantifiable.

2. They had to be capable of being simulated.

3. They had to be face valid (i.e., they had to represent situations that could actually occur in the commercial flight deck environment).

Based on these criteria, factors from each of the factor categories of the classification scheme presented in section 4 were selected. They included the following:

1. Two situation factors.

   a. One aircraft factor (i.e., equipment design, specifically, the design of the flight management computer (FMC) control display unit (CDU)).
   b. One task factor (i.e., the level of task loading or task demands).

2. One operator factor (i.e., the amount of user experience with the FMC CDU).

3. Two causal factors (i.e., distractions and malfunctions).

It should be noted that in the classification scheme, "excessive task demands" were also categorized as a causal factor; the particular combination of situation and operator factors selected here could result in excessive task demands (or workload), thus illustrating that operator and situation factors (contributing factors) can, in combination, constitute a causal factor.

5.2 SPECIFIC FACTOR-ERROR HYPOTHESES EVALUATED

The hypotheses concerning these factors were fairly straightforward. In much previous work (refs. 7 and 20), it has been shown that an FMC CDU (fig. 5-1) can be difficult to use in high workload conditions. Many airlines instruct their crews not to use the CDU below a certain altitude. It was hypothesized that this less than "user friendly" design, coupled with a task and a situation that induces high workload, would lead to manual input errors in programming the CDU or worse, in the programming not being completed in time to meet a requested clearance, resulting in a pilot deviation. It was further hypothesized that the error frequency would be increased even more if distractions or malfunctions occurred during the programming process. It was also hypothesized that the mechanism of malfunction and resulting error type would depend on the level of experience of the user. Experienced users, because of their skill-based proficiency, would more likely make an error of judgment in trying to use the CDU when that decision was questionable and would be more likely to make "slips" (i.e., manual mistakes in button

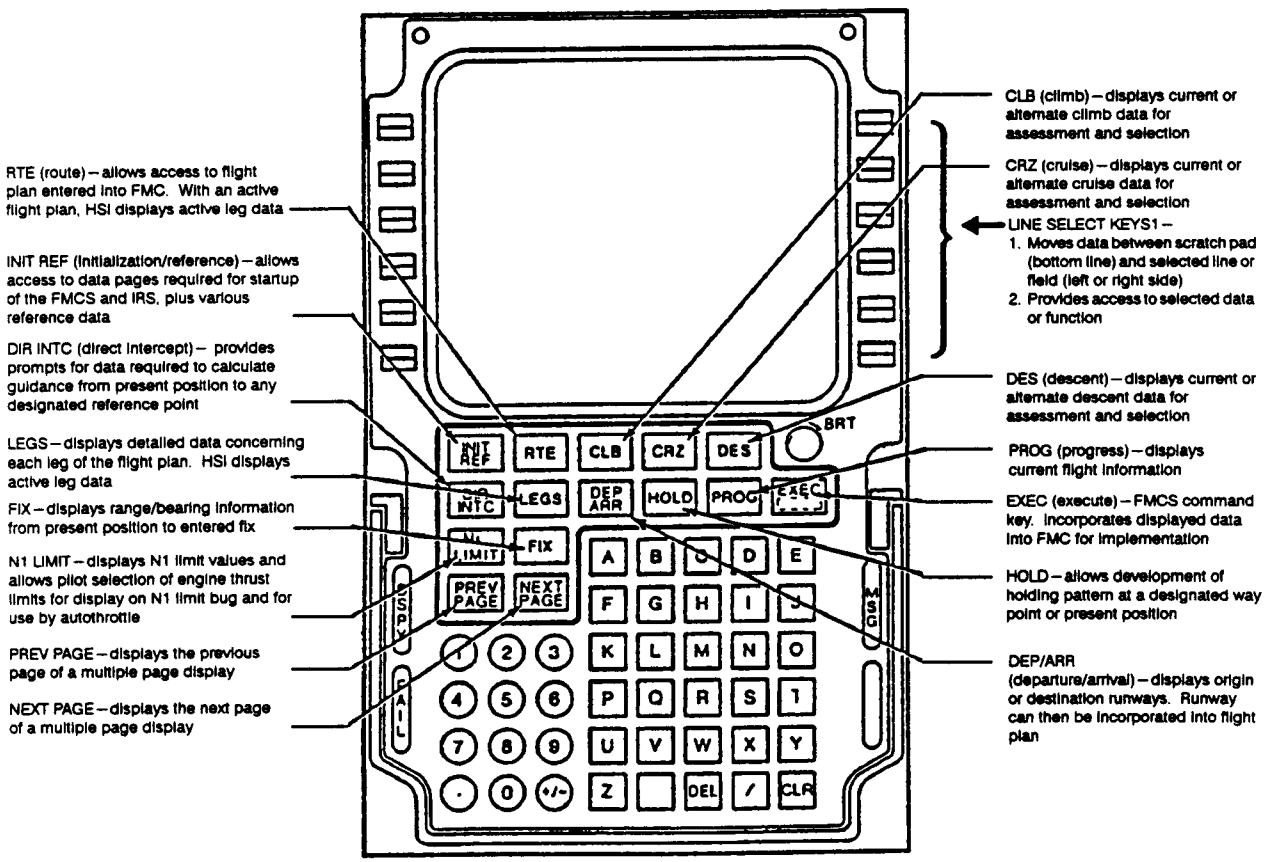

Figure 5-1. FMCS CDU Key Functions

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pushing when the intention was correct). Inexperienced users would be more likely to make errors of intention, because while operating in a knowledge-based mode (see ref. 17), they would be more likely to become confused about the right sequence of CDU button pushes required to perform the desired function. It was assumed that the task demands and the distractions and malfunctions would exert their influence simply by stressing the attention capacity of the pilot; when that capacity is exceeded, actions are omitted or performed so rapidly that a speed-accuracy tradeoff results.

6.0 ANALYTICAL EVALUATION OF HYPOTHESES

One method of confirming the hypothesized factor-error relationships discussed in section 5 is to review epidemiological data. In aviation, one source of these kinds of data is accident and incident databases. Our strategy was to review these data for cases in which the specified combination of factors did, in fact, contribute to the errors hypothesized. The original intention was to search a variety of databases. It became quickly evident, however, that the utility of many of the databases was limited, either by difficulty of access or by the kinds of factors that they documented.

6.1 REVIEW OF ASRS REPORTS

The decision was made to concentrate primarily on the ASRS database, which included voluntary incident reports from all sectors of the aviation community. This database is the most extensive and detailed available, in terms of the number of reports, the sophistication of the retrieval process, and the kinds of factors that are likely to be mentioned. While the database is biased toward incidents that are likely to be detected by more than the crew of the aircraft involved (e.g., altitude deviations), it does provide an opportunity for any reporter to describe any kind of incident. The ASRS database is also easy to access. Incident reports are much more likely to mention a variety of contributing factors than accident reports, which mention only those factors that can be documented to the extent that they will withstand legal scrutiny.

A member of the Boeing team performing this contract attended a one week training class at Battelle's ASRS facility at NASA Ames in order to learn the reporting and retrieval structure for ASRS data. ASRS reports can be retrieved by a number of predesignated "diagnostic categories," and by key words included in the narrative. Based on an understanding of the best way to retrieve the reports of interest, which involved a combination of searching prespecified diagnostic categories and searching for key words in the narrative, we requested a number of database searches to try to identify incidents in which the hypothesized combination of factors was relevant to a reported incident. Four searches were initially performed:

1. FMC programming anomalies (309 reports retrieved).

2. Manual input errors (158 reports retrieved).

3. Multiple task demands for low- and high-experienced pilots (60 reports retrieved).

4. Recent flightcrew upgrades and downgrades (18 reports retrieved).

Table 6-1 depicts the cover page of the search on FMC programming anomalies. This provides information on the way the search was performed and the number of cases that resulted from the search. The multiple task demands task was searched only for cases involving very high (> 28 000) and very low (< 2000) total hours to evaluate the effect of experience level on the type of errors that are made when

Table 6-1. Example of Cover Sheet of ASRS Search

Battelle
Columbus Division
ASRS Office
625 Ellis Street
Suite 305
Mountain View, California 94043
Telephone (415) 969-3969

May 17, 1988

Mr. William Rogers
Boeing Commercial Airplanes
P.O. Box 3707, MS 9606
Seattle, WA 98124-2207

Special Request No. 1333
Flight Management Computer Programming Anomalies

Dear Mr. Rogers:

In response to your request of NASA's Aviation Safety Reporting System, the enclosed printout contains 309 reports referencing problems with Flight Management Computers (FMCs), and ten reports specifically referencing Control Display Units (CDUs). At the time of this search, the ASRS database contained 28,933 full-form records of all types received since January 1, 1982. (There were also 11,636 abbreviated-form records in the database, but since FMCs and CDUs are not identified in these records, they were not included in the search.) Attached is an explanation of the coded information contained in your printout.

Due to the structure of the ASRS database, there is no way to specifically search for programming problems of FMCs or CDUs. Therefore, your printout of 309 FMC reports were retrieved solely because they referenced FMCs. The same holds true for the ten CDU reports. As per our telephone conversation, we are sending you all reports for you to apply your own screening biases.

Please note with care the attached caveat regarding statistical use of ASRS information and the point Mr. Reynard makes in his covering memorandum to recipients.

We hope you find this information both interesting and useful, and apologize for the delay in getting it to you. If we may provide any additional assistance or clarification, please don't hesitate to contact us at your convenience. We also welcome any comments you may have.

Sincerely,

Mitzi Wagner

Mitzi A. Wagner
Researcher

Ed Cheaney

Ed S. Cheaney
ASRS Research Coordinator

MAW

Enclosure

9-U80183R1-23

dealing with multiple task demands. The experience level was also the focus of the search on upgrades and downgrades.

6.2 RESULTS OF THE ASRS SEARCH

The cases of the search on the FMC were perused in some detail. A summary of the incidents that resulted from FMC programming anomalies is provided in table 6-2. There were numerous reports that included the combination of factors of interest in the narrative description of the incident. For example, the incident narrative presented in table 6-3 illustrates the effect of multiple task demands, a difficult procedure to perform with the CDU; time constraints; and distractions on an error in judgment in using the CDU, which resulted in a pilot deviation. While a formal tabulation has not been done, it appears that a number of cases from this search substantiate the notion that the combination of factors investigated lead to errors resulting in undesirable consequences. However, this by no means provides a quantification of the error probability resulting from this combination of factors.

The other searches have not been analyzed; review of these searches and a more complete report will be performed as part of the second year's effort. As appropriate, searches will be initiated to provide preliminary data on other factor-error relationships.

Table 6-2. Summary of Incidents of FMC CDU Programming Anomalies

ASRS Search	

• 309 out of 29 000 reports (from 1/82 to 5/88) on FMC/CDU problems
• 44 altitude deviations
  • 19 distracted due to CDU
  • 8 VNAV disc. unnoticed
  • 7 insufficient time to program
  • 6 x'ing waypoint confused
  • 4 descent constraints entered wrong
	• 43 lateral deviations
	  • 14 incorrect route programmed
	  • 10 FMC nav error
	  • 8 distracted due to CDU
	  • 7 while in holding
	  • 3 insufficient time to program
	  • 1 runway change

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Table 6-3. Example of Narrative From FMC CDU Programming Anomalies Search of ASRS Database

ACCESSION NUMBER	: 38908
DATE OF OCCURRENCE	: 8411
REPORTED BY	: FLC
PERSONS FUNCTIONS	: FLC, PIC.CAPT; FLC, FO; ARTCC, RDR
FLIGHT CONDITIONS	: VMC
AIRCRAFT TYPE	: WDB
NARRATIVE	: I SERVED AS CAPTAIN ON ACR BETWEEN BOS AND EWR IN A WDB ACFT. WE ORIGINALLY FILED FOR FL350 BUT WERE HELD DOWN TO 16 000' DUE TO CENTER CONGESTION. THE POINT HERE IS THAT WE HAD DONE NO PREFLT FOR THE LOW ALT AIRWAYS STRUCTURE. OUR CLRNC READ: CLRD TO EWR ARPT–V205 MOBBS, DIRECT EWR–MNTN 16 000'. AT APX 0900 EST WE WERE CLEARED TO DESCEND TO 9000'. PASSING APX 12 000' WE WERE ISSUED A CLRNC THAT READ DESCEND TO 6000', CROSS THE SPARTA VOR 23 DME AT OR BELOW 8000'. THE F/O WAS FLYING AND I IMMEDIATELY STARTED ENTERING DATA INTO THE FMS NECESSARY TO PORTRAY THE SPARTA VOR (SAX–115.7 MH) ON THE EHSI MAP DISPLAYS. THIS IS ACTUALLY A RATHER TIME CONSUMING TASK. FIRST SINCE OUR ROUTE OF FLT DID NOT GO OVER SPARTA, I HAD TO LOOK UP ITS IDENTIFIER ON THE LOW ALT CHART, 2) THEN CENTER DIRECT TO THIS IDENTIFIER TO FIND WHAT RADIAL WE WOULD PROCEED INBOUND ON, THEN 3) REVERSE THAT AND ADD THE DESIRED DME, THEN, 4) ENTER DIRECT TO THAT FIX, THEN 5) CLEAR THE ROUTE DISCONTINUITY, THEN 6) EXECUTE THE REVISED ROUTING. LEAVING APPROXIMATELY 9500' IN DESCENT AND PRIOR TO COMPLETING THE KEYBOARD WORK, THE CTLR CALLED AND SAID THAT WE WERE ALREADY 5 MILES PAST THE 8000' XING POINT. AS THIS WAS ONLY ABOUT ONE MINUTE AFTER HE ISSUED THE XING RESTRICTION, WE MUST HAVE BEEN VERY CLOSE TO IT WHEN WE ACCEPTED THE CLRNC. WE HAD NO WAY OF KNOWING THIS HOWEVER UNTIL THE XING FIX COULD BE PORTRAYED ON THE EHSI. THE 23 DME ON THE V205 RADIAL ACTUALLY MAKES UP SILKY INTERSECTION. HAD THE CTLR USED THAT TERMINOLOGY INSTEAD OF DESIGNATING A DME XING, WE WOULD HAVE REALIZED THAT WE WERE TOO CLOSE TO THE XING FIX TO CROSS IT AT THE ALT SPECIFIED AS HE READ US THE ORIGINAL CLRNC. AS SILKY INTERSECTION WAS ON OUR ROUTE OF FLT, AND IT WAS PORTRAYED ON THE EHSI AND SEVERAL PAGES OF THE FMS, ALL THE CONFUSION COULD HAVE BEEN AVOIDED.
CALLBACK/COMMENTS	: NONE
LOC ID (LOCATION IDENTIFIER)	: ZNY; SAX
AIRCRAFT TYPE	: WDB
CREW SIZE	: 2
WINGS, GEAR, SURFACE, ENGINE	: LOW, RETRACT, LAND, TURBOJET
NUMBER OF ENGINES	: 2
ADVANCED COCKPIT	: DISPLAY, NAVCTL, FLTENG
OPERATOR ORGANIZATION	: ACR
OPERATION	: PAX
FLIGHT PLAN TYPE	: IFR
FLIGHT PHASE	: DSCNT, MNTN
AIRCRAFT SUBSYSTEMS	: OPPROC.3462.EFX
AIRCRAFT POINTER	: P1, P2
AIRCRAFT HANDLE	: A1

Special Request No. 1333

Flight Management Computer Programming Anomalies

7.0 EMPIRICAL EVALUATION OF HYPOTHESES

A much more rigorous evaluation of the factor-error hypotheses was pursued assessing errors in piloted simulations. The aim of these simulations was to manipulate the factors of interest in realistic flight scenarios and assess the effect of the different combinations on the type and frequency of resulting errors.

7.1 OBJECTIVE

There were three objectives of the experiment:

1. To test hypotheses concerning the frequency and type of pilot errors that result from a specified combination of operational factors.

2. To demonstrate the kind of experimental methodology that could serve as a useful tool for error evaluation. While error prediction and modeling is the ultimate goal, better empirical test methods are also needed to evaluate the error potential of different design components early in the design process.

3. To provide a baseline for evaluation of future CDU modifications. Once error frequencies have been established for the present design of the CDU with the combination of other factors previously described, this can be used as a baseline to assess if new CDU design concepts actually provide a reduction in error frequency under the demanding conditions simulated.

As mentioned in section 5, the specific factors we selected as likely to impact the pilot's error frequency included the design of the FMC CDU, task demands, distractions, malfunctions, and pilot experience level with the CDU. The experiment was designed on the general hypothesis that the current CDU design makes it difficult to perform certain CDU functions in high-workload conditions, particularly with other flight deck distractions and/or malfunctions. Even restricting the CDU's use to above certain altitudes, we believe that factors can combine to make its use difficult. This can lead to errors ranging from simple slips (hitting the wrong buttons), which are quickly corrected, to more serious errors such as trying to program a clearance restriction and violating that restriction before the programming is complete. The kinds of errors that occur are hypothesized to vary with the experience level of the user (see sec. 5.2).

7.2 SCENARIOS

An FMC-equipped airplane was flown on autopilot with vertical navigation (VNAV) and lateral navigation (LNAV) connected and a single crewmember was required to perform a series of air traffic control (ATC)-requested flight plan changes in flight using the CDU. The scenarios were developed to address CDU functions that were hypothesized to be difficult to perform. This primarily involved using the "Legs" page of the CDU (see fig. 7-1) to tactically change the flight plan in flight. Workload was designed

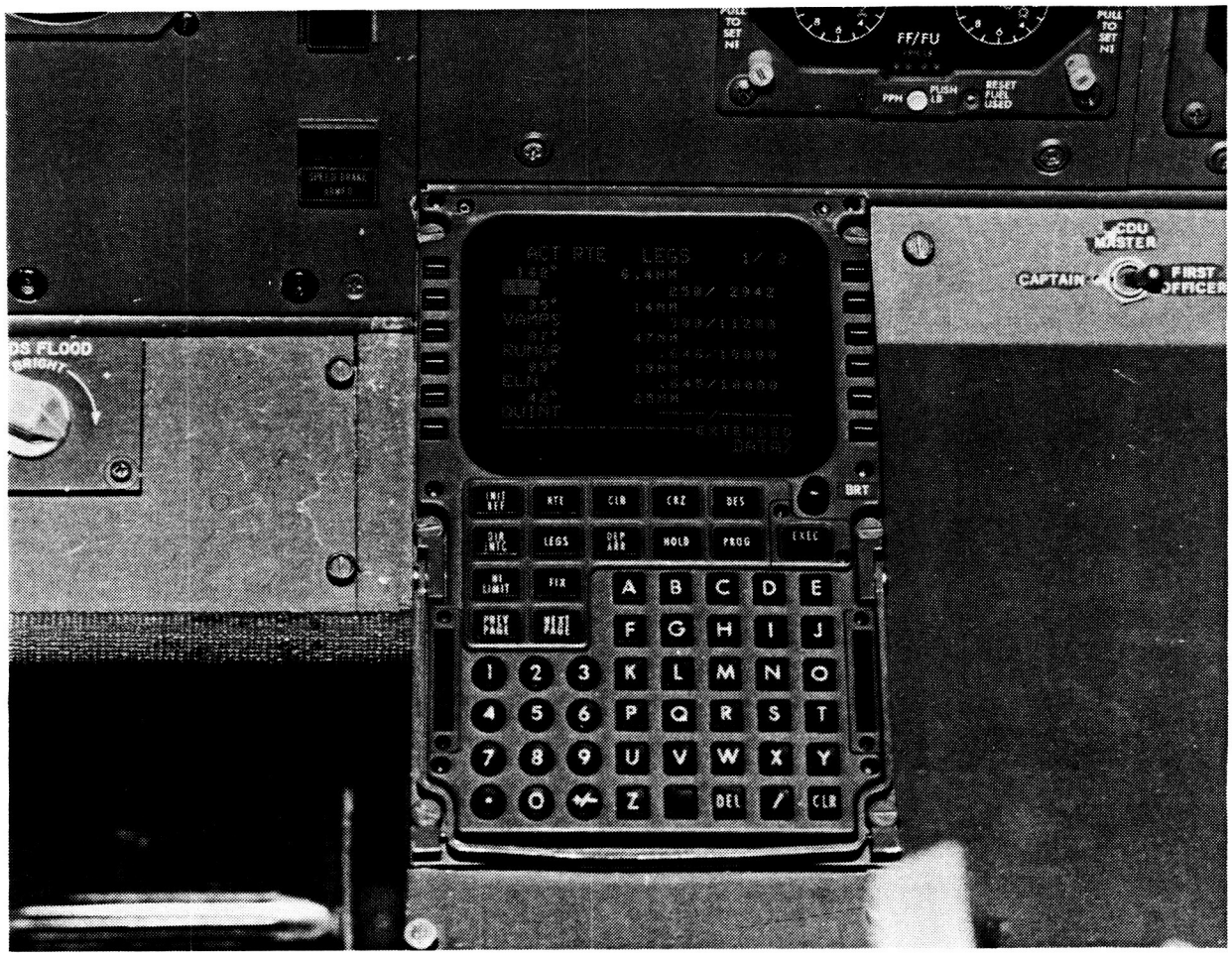

Figure 7-1. CDU Legs Page

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to be generally high by requiring the pilot to perform multiple tasks (e.g., monitoring displays and interacting with ATC) and was further varied by manipulation of the following factors:

1. Complexity of ATC clearance and resulting CDU task. Clearances can vary in how difficult it is to program them with the CDU, depending on the restrictions involved and the terms the clearance is defined in. In our scenarios, the number of button pushes required to program the clearances on the CDU varied between approximately 15 and 30.

2. Time available to meet the clearance. Often when a clearance is given by ATC, the time to respond and make the clearance is minimal. We simulated this by allowing either 1 or 2 min between the time the clearance was given and when the point the clearance had to be met would be reached. It was important that the decision to use the CDU was in a "gray" area; the pilot knew its use would lead to more fuel-efficient flight, but could result in a pilot deviation if not done quickly and accurately. We made this decision more difficult by supplying the pilot with non-EFIS displays (fig. 7-2), which do

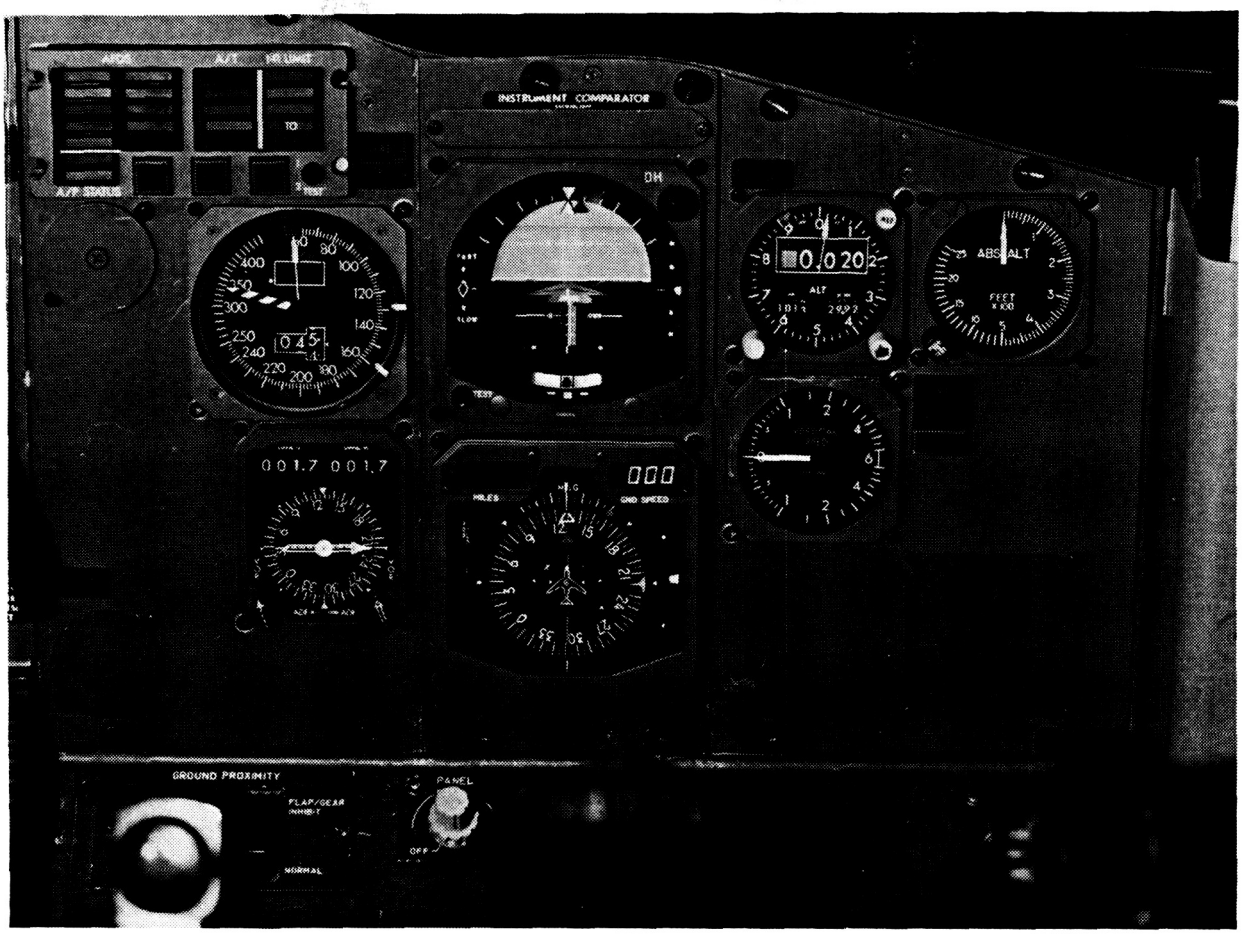

Figure 7-2. 737-300 Non-EFIS Display Configuration

9-U90183-7

not provide the situational awareness that the electronic flight instrument system (EFIS) displays (fig. 7-3) do.

3. Familiarity of the route. We designed the experiment so that the subjects had to fly routes they were familiar and unfamiliar with. The hypothesis was that the unfamiliar routes would create greater task demands and thus result in higher error frequencies.

Flights were performed with and without an additional distraction and/or malfunction, such as an ATC request, a LNAV or VNAV disconnect, or other cautionary message. A questionnaire was administered that asked for background data, including experience on the CDU. These data will be correlated with the various error measures.

Each subject received four 30-min flights, each including the end of climb, a short cruise phase, approach, and stabilization for landing. Each subject was briefed on each filed flight plan prior to the flight. Four "miniscenarios" were inserted into each flight. Each miniscenario began with an enroute clearance change and ended with that clearance being met or deviated from. The four initial flight plans, the same

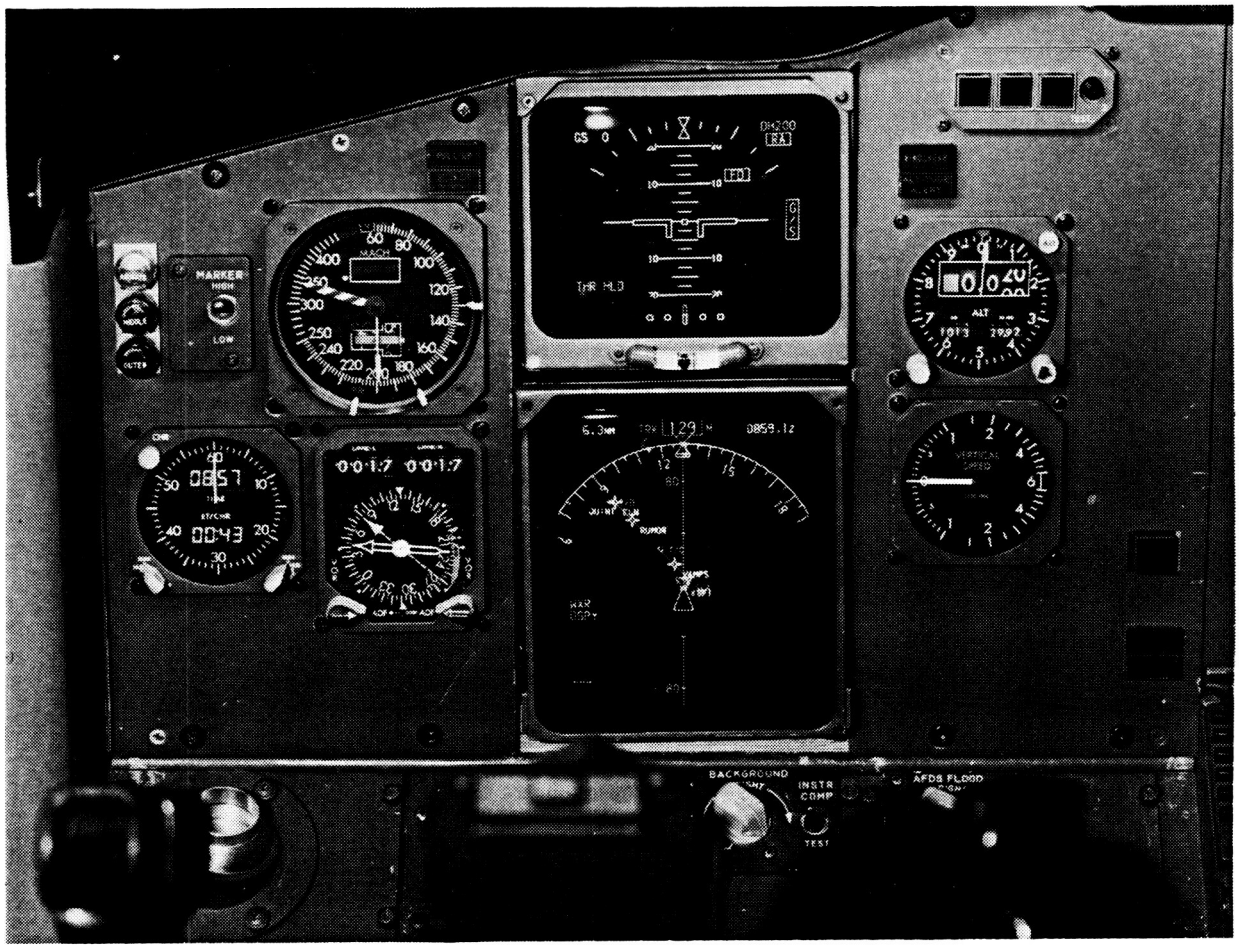

Figure 7-3. 737-300 EFIS Display Configuration

9-U90183-8

flight plans as modified by inflight ATC clearances, and the ATC scripts that requested the inflight path changes to meet specific clearances, are included as appendix 3. Each flight included a departure and arrival point and five or six waypoints. The routes were Seattle to Moses Lake, Moses Lake to Seattle, Boston to New York, and New York to Boston.

Each miniscenario represented a specific combination of the independent variables. There were five variables with two levels each (high or low CDU task complexity, high or low route familiarity, distraction/no distraction, malfunction/no malfunction, and short or long time to make the clearance), making possible 32 (2 x 2 x 2 x 2 x 2) combinations. The experimental design allowed 16 (4 miniscenarios x 4 flights) of the combinations to be tested (see table 7-1 for a summary of the combinations tested).

7.3 EXPERIMENTAL PROCEDURE

The experiments were performed in a Boeing engineering simulator configured as a 737-300 (fig. 7-4). The experimental team included two confederates: one serving as a second crew member and ATC and

Table 7-1. Factor Combinations Tested in Simulation

ROUTE FAMILIARITY								
	High				Low			
CDU PROGRAMMING COMPLEXITY								
	High		Low		High		Low	
LEAD TIME	Short	Long	Short	Long	Short	Long	Short	Long
Distraction: Absent / Malfunction: Absent	Seattle Moses Lake MS #4		Moses Lake Seattle MS #2		Boston New York MS #4		New York Boston MS #2	
Distraction: Absent / Malfunction: Present				Seattle Moses Lake MS #1				Boston New York MS #1
Distraction: Present / Malfunction: Absent	Moses Lake Seattle MS #1	Seattle Moses Lake MS #2	Seattle Moses Lake MS #3	Moses Lake Seattle MS #3	New York Boston MS #1	Boston New York MS #2	New York Boston MS #3	Boston New York MS #3
Distraction: Present / Malfunction: Present	Seattle Moses Lake MS #4				New York Boston MS #4			

MS – Miniscenario

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the other coordinating all aspects of the experiment and observing. The confederate pilot had EFIS displays and the experimental subject had non-EFIS displays.

Each cab session was 4 hr: 1 hr for instructions to the pilot and four 1/2-hr simulations separated by rest intervals during which the next simulation was readied and the subject familiarized with the flight plan for the next scenario. Pilots received the four flights in a counter-balanced order. Each flight simulation started with an FMC-stored flight plan and, as mentioned, was scripted with specific events, such as ATC messages including positional and clearance changes to the plan and malfunctions and distractions occurring at specified times in the simulation.

7.4 SUBJECTS

We recruited Boeing flightcrew training pilots for this experiment, all 737-300 type rated, with varying degrees of experience with FMC-equipped airplanes. Eight subjects performed the experiment, but the data of the first two will not be analyzed because changes to the experimental procedure were made subsequent to these subjects' sessions.

7.5 ERROR MEASURES

A variety of pilot error measures were collected. The primary error measure collected was CDU button pushes for each CDU "miniscenario" (table 7-2 shows output of the CDU monitoring program). CDU error measures included the number of button pushes that deviated from the "optimal" path for each miniscenario, as well as where the deviations occurred, what button pushes constitute each deviation, the time for each button push, and the timing of the entire sequence of button pushes. Also collected was

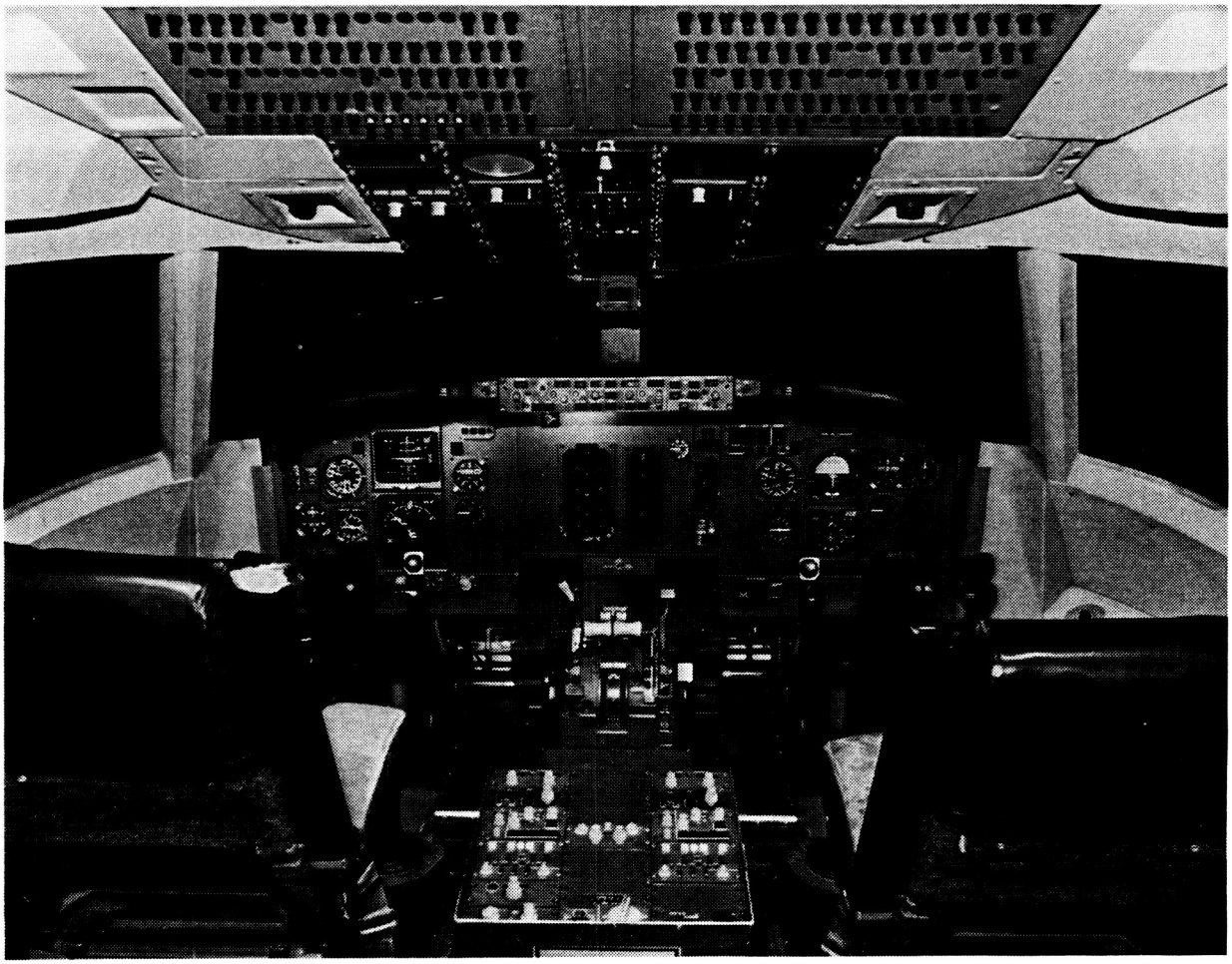

Figure 7-4. 737-300 Configuration Used for Error Simulation Studies

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a time-referenced record of altitude, speed, track, latitude, longitude, etc., which will be used to assess pilot deviations. Data such as speed brake use, flap settings, and throttle settings were collected to assess how efficiently the scenario was flown (table 7-3 lists all performance data collected). An observer manually recorded some data, such as when ATC messages were received and responded to, responses to nonnormals and malfunctions, timing of key strategical decisions, acknowledgments of committed errors, problems, and general pilot comments.

This experiment was not completed. A replication will be run, and the data of all subjects will be analyzed and reported in the second year of the program (see sec. 8). From experimenter subjective observations during the experiment, however, it appears that many of the errors that were hypothesized and illustrated in the ASRS reports were committed during our simulations. For example, subject 3 did not make either the altitude (fig. 7-5) or speed (fig. 7-6) restriction given for ORTIN (miniscenario 4) in the Moses Lake to Seattle flight. We are optimistic that the analyses of the results will show some interesting findings consistent with the hypotheses.

Table 7-2. Typical Output of CDU Monitor Program

CDU Keypush History
Date:01/19/89 Time:11:23:00.0

Subject 3 Scenario 4

PH = Page Header
FK = Function Key
LS = Line Select
TX = Text

11:22:00.6 FK: INIT REF
11:22:00.8 PH: ACT PERF INIT 1/2
11:22:01.0 PH: PERF INIT 1/2
11:22:01.6 LS: 6 Left
11:22:01.9 PH: INIT/REF INDEX 1/1
11:22:07.4 LS: 2 Left
11:22:07.9 PH: POS INIT 1/3
11:22:08.6 TX: KBFI
11:22:09.9 LS: 2 Left
11:22:11.2 LS: 6 Right
11:22:11.5 PH: RTE 1/1
11:22:12.4 LS: 1 Left
11:22:13.4 TX: KMWH
11:22:14.6 LS:1 Right

11:22:19.4 FK: INIT REF
11:22:20.7 PH: PERF INIT 1/2
11:22:20.8 TX: 11.0
11:22:22.8 LS: 1 Left
11:22:23.8 TX: 5
11:22:24.4 LS: 4 Left
11:22:25.2 TX: 25
11:22:25.7 LS: 5 Left
11:22:28.2 TX: 190
11:22:29.1 LS: 1 Right
11:22:32.6 FK: RTE

U90183oo3-11

Table 7-3. Performance Data Collected During Simulation

- Throttle position engine 1 and 2
- Airspeed, altitude, and track
- Flap position
- Gross weight of fuel
- Speed brake position
- Lateral and vertical deviation from flight path
- Latitude and longitude
- Engine 1 and 2 N1
- MCP settings
  - Heading -Altitude -Speed
  - Autopilot A -Autopilot B
  - LNAV -VNAV
  - LVL CHG -HDG SLCT -ALT HLD

U90183-pk3-12

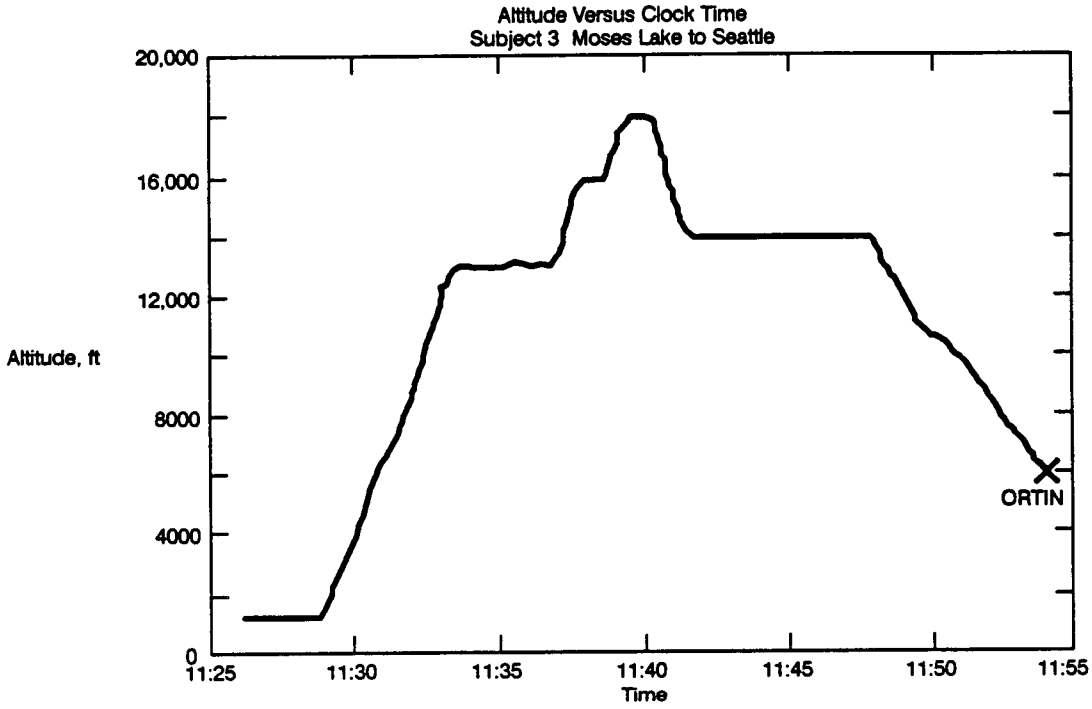

Figure 7-5. Altitude Deviation at ORTIN

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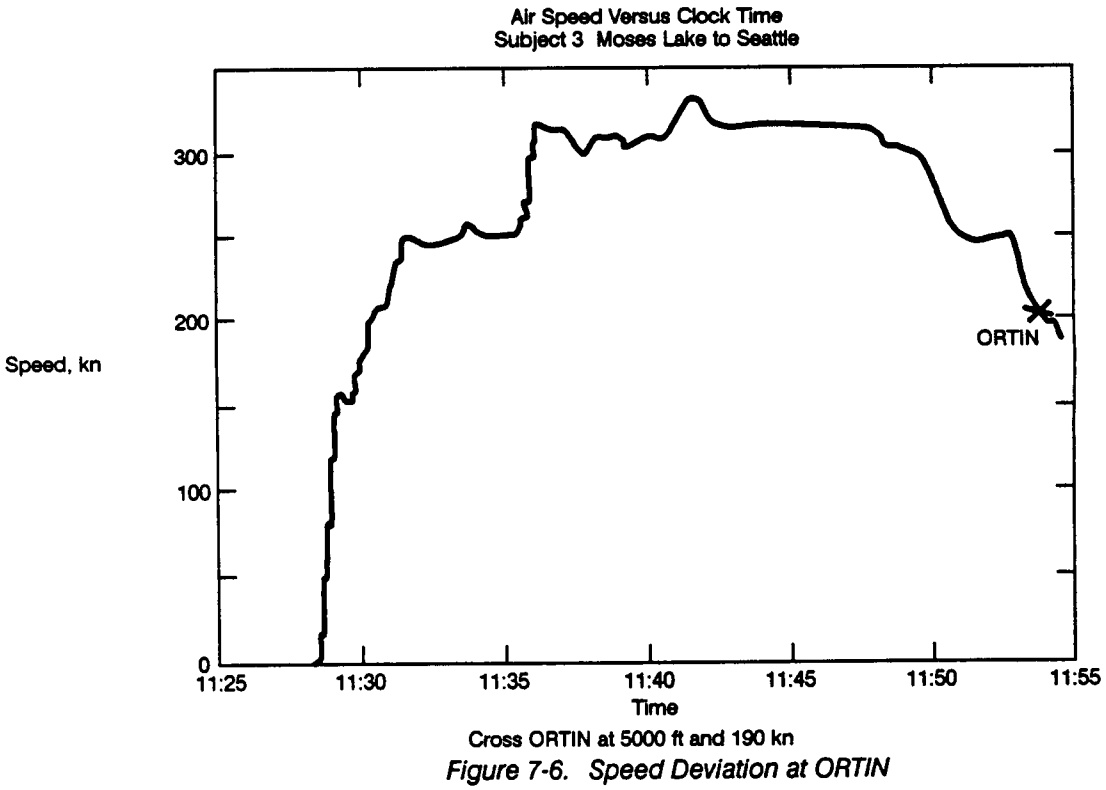

Figure 7-6. Speed Deviation at ORTIN

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8.0 FUTURE TASKS

The first experiment of the second program year will be to perform a replication of this study. The replication will simply repeat the first simulations to increase the statistical power of the tests. This is considered a baseline study and will establish methods and measures that can be used in succeeding studies as well as establish an empirical error frequency baseline for the particular factor cluster chosen.

A second study will be performed that will test modified factor-error hypotheses; it is assumed that the study reported here will result in changes to the original hypotheses. Another objective of the second study will be to confirm results of the first study (which was performed with Boeing pilots) with line pilots (the experience and skill levels are predicted to be different between the two populations). If no refinements of the initial hypotheses are required as a result of the first experiment, then the second study will simply repeat the first experiment with line pilots rather than Boeing pilots.

Based on expertise in the factor areas, we will develop and test methods that reduce the error frequency shown to result from the selected combination of underlying factors. The focus of this effort will be to develop and test design modifications that reduce the error probability, although modification of other factors of the factor cluster, such as task procedures or training, will also be considered.

National Aeronautics and Space Administration
Langley Research Center
Hampton, Virginia 23665-5225
September 1989

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APPENDIX 1

CATEGORIES OF FACTORS, MECHANISMS, AND ERRORS COMPILED FROM THE LITERATURE REVIEW

Gerbert, K. and Kemmler, R., 1985

Factors

Physical factors
Psychological factors
Pilot's proficiency factors
Environmental factors
Mission requirement factors
Organizational and supervisory factors
Technical and design factors

Reason, J., 1985

Slips and Mistakes

Skill-based slips
Rule-based mistakes
Knowledge-based mistakes

McRuer, D.T., Clement, W.F., and Allen, R.W., 1980

Single Channel Operations—Compensatory

Extreme command or disturbance amplitude (unexpectedly large command or extreme environment)
Extreme command or disturbance bandwidth (broadband input signal noise)
Controlled-element change (malfunction/failure in controlled element)
Reduced attention field (poor signal/noise ratio)
Reversals (misperception of error sign, naivety)

Multi input Operations

Divided attention and perceptual scanning
Reduced attentional field
Illusions, kinetosis

Green, R.G., 1985

Stress

Environmental stress
Acute reactive stress
Life stress

Borowsky, M.S. and Wall, R., 1983

Mistakes versus Experience Level

Types of flights
Offensive maneuvers
Control loss
Cross country flights
Carrier landings
Overrun and undershoot during landing
Inadequate flight preparation
Failed to maintain flying speed
Improper use of flight controls in air
Misjudged distance, altitude, or position
Improper response and poor technique for landing
Physical and mental condition of pilot
Violation of existing regulations and instructions

Rockwell, T.H. and Giffen, W.C., 1987

Critical Inflight Event Model

Errors:
1. Inadequate preflight
2. Fails to recognize early warnings of problems
3. Fails to do sequence check
4. Decides to fly despite system discrepancies
5. Fails to recognize early warnings
6. Fails to monitor instrument readings
7. Fails to notice small discrepancies in flight sensations
8. Fails to notice lack of agreement of related instruments
9. Diagnostic error
10. Error is estimation of urgency
11. Improper corrective action
12. Poor emergency flying skills

Pilot Fuel Mismanagement Model

Errors:

1. Fuel system status
   a. No visual check of fuel status
   b. Failure to drain tanks
   c. Failure to check caps and vents
   d. Failure to select proper tank
2. Fuel requirements
   a. Miscalculate route miles
   b. Miscalculate fuel consumption and power setting
   c. Failure to get winds aloft
   d. Failure to plan an alternate
   e. Failure to account for traffic delays
3. Fuel added
   a. Failure to observe refueling
4. Enroute procedures
   a. Poor leaning procedure
   b. Improper tank selection schedule
   c. Failure to use proper switching procedures
   d. Failure to update ground speed
   e. Improper power management
   f. Poor selection of refueling airport
   g. Failure to have NOTAMS
5. How compensated for
   a. Poor emergency flying skills
   b. Fails to use ATC assistance

Model for VFR Flight into IMC

Errors:

1. Failed to get NOTAMS big weather picture and weather forecast (used wrong source)
2. Failed to understand weather
3. Failed to use weather in flight planning
4. Failed to prepare navigation alternatives for weather contingencies
5. Failed to get correct weather
6. Poor fuel management in face of weather changes
7. Failed to note changes in weather enroute
8. Failed to note forecast would not hold
9. Failed to get weather updates
10. Failed to let ATC know of pending weather induced problems
11. Failed to consider 180° or diversion before IMC
12. Failed to note weather trend

13. Failed to use arrival weather sources
14. Failed to keep aircraft under control
15. Failed to contact ATC for assistance

Lubner, E.G. and Lester, L.F., 1987

Model To Predict Aviation Events

Exposure (time flown and aviation situation)
Environmental and agent variables (tractable and intractable)
Value of flying (motivation to fly)
Personal dispositions
- Cognitive (hazardous thoughts, attitudes, and attention)
- Noncognitive (I/E locus of control, ego strength, risk taking, and mental health)
- Physical condition
- Alcohol use
- Drug use—prescription or not
- Chronic disorders (e.g., high blood pressure)
- Static physical defects (e.g., impaired vision)

Stress
- Life events
- Buffers (social and instrumental support)
- Coping

Flying experience
- Certificate/rating
- Time spent flying
- Safety behaviors
- Familiarity with A/C

Mediating processes
- Situation-specific responses
- Judgment and decisions

Lubner, M.E. and Lester, L.F., 1987; Bush, G. and Diehl, A., 1984; Lester, L.F. and Bombaci, D.H., 1984

Hazardous Thought Patterns

Antiauthority
External control
Impulsivity
Invulnerability
Macho

Feggetter, A.J., 1982

Accident Investigation Checklist Development

1. Cognitive system
   a. Human information processing system
      (1) Sensory
      (2) Perception
      (3) Attention
      (4) Memory
      (5) Decision
      (6) Action
      (7) Monitoring
      (8) Feedback
   b. Visual illusions
   c. False hypothesis
   d. Habits
   e. Motivation
   f. Training
   g. Personality
   h. Fear
2. Social system
   a. Social pressure
   b. Role
   c. Life stress
3. Situational system
   a. Physical
      (1) Physical stress
      (2) Physical condition
      (3) State of nutrition
      (4) Drugs
      (5) Smoking
      (6) Alcohol
      (7) Fatigue
      (8) Sleep loss
   b. Environmental stress
      (1) Altitude
      (2) Speed and motion
      (3) Visual
      (4) Glare
      (5) Disorientation
      (6) Temperature
      (7) Lighting levels

(8) Noise
(9) Vibration

c. Ergonomic aspects
(1) Design of controls
(2) Design of displays
(3) Seating
(4) Presentation of material
(5) Policy of dealing with emergencies

Feggetter, A.J., 1985

DBMS Development on Accident Investigation

1. Cognitive system
   a. Human information processing system
      (1) Inadequate perceptual cues
      (2) Misleading perceptual cues
      (3) Attentional problems
      (4) Distraction
      (5) Inappropriate decision
      (6) Inappropriate feedback
      (7) Memory difficulties
      (8) Inappropriate action
   b. Visual illusions
   c. False hypothesis
   d. Disorientation
   e. Personality
   f. Overconfidence
   g. Motivation
   h. Arousal
   i. Slow response time
   j. Habits
   k. Training
   l. Supervision
   m. Tasking
   n. Briefing
   o. Workload
2. Social system
   a. Crew cooperation
   b. Life stress
   c. Rule breaking
   d. Social pressure
   e. Role conflict

3. Situational systems
    a. Fatigue
    b. Physical stress (health)
    c. Drugs
    d. Alcohol
    e. Nutrition
    f. Diurnal rhythms
    g. Circadian rhythms
    h. Environmental stress
    i. Time pressure
    j. Get-home-itis
    k. Operational pressure
    l. Unfamiliar aircraft
    m. Weather
    n. Ergonomics

Green, R.G., 1984

Stress and Accidents

1. Stress
    a. Environmental stress
        (1) Noise
        (2) Vibration
        (3) Heat
        (4) Cold
        (5) Mild hypoxia
        (6) Sleep deprivation
    b. Acute reactive
    c. Life stress
        (1) Bereavement
        (2) Divorce
        (3) Moving house
        (4) New job

Stoklosa, J.H., 1983

Human Performance

1. Human performance factors
    a. Behavior
        (1) A 24- to 72-hr history
        (2) Operator behavior

(3) Life habit patterns
(4) Life events

b. Medical
   (1) General health
   (2) Sensory acuity
   (3) Drug and alcohol ingestion
   (4) Fatigue

c. Operational
   (1) Training
   (2) Experience familiarity habit patterns
   (3) Operating procedures
   (4) Company policy

d. Task
   (1) Task information
   (2) Task components
   (3) Task time relation
   (4) Workload

e. Equipment design
   (1) Workspace interface
   (2) Display and instrument panel design
   (3) Control design
   (4) Seat design and configuration

f. Environmental
   (1) External conditions
   (2) Internal conditions
   (3) Illumination
   (4) Noise and vibration

Platenius, P.H. and Wilde, G., 1987

"Intuitively" Categorized Item-Sets (excluding purely biographical and flying-experience items)

1. Life events and preoccupations-included 14 'events' generally family or job related matters.
2. Risk acceptance-included about 12 items designed to assess degree to which respondents tended to advocate, prefer, or actually carry out risky activities.
3. Lack of humor appreciation-respondents asked to indicate which of 17 syndicated comic strips they read regularly.
4. Asocial or sedentary hobbies-respondents were asked to check off which of 27 leisure activities in which they like to engage.
5. Medical symptoms-respondents were asked to pick which of a list of 14 symptoms, largely stress-related, applied to them.
6. Perceiving oneself as unsuccessful.
7. Lack of initiative or self-control and dislike of constraints.

8. Social disability or loneliness.
9. Alcohol use-one questionnaire was, "does the consumption of alcohol add to your pleasure in social affairs?" (greatly, considerably, moderately, slightly, or not at all).
10. Accidents and violations in automobile driving.
11. Underattribution of accident causes-13 factors were listed that could be considered as causes of accidents, and respondents were asked to "estimate the percentage of fatal accidents in which (each one) would be listed as a partial cause."

Becker-Lausen, E., Norman, S., and Pariante, G., 1987

Information Sources for Human Error in Aviation

ASRS categories
Behavior
- Aggression
- Complacency
- Emotional trauma
- Fatigue
- Illness
- Inadequate human resources
- Incapacitation
- Interpersonal relationship
- Personal injury
- Physical discomfort
- Resource utilization
- Schedule pressure
- Social pressure
- Unfamiliar with operation
- Unprofessional attitude

Each of the above categories are paired by the analyst with the individual involved; i.e., pilot/behavior/personal injury, controller/behavior/fatigue, etc.

Feggetter, A.J., 1982

Human Factors Aspects of Aircraft Accidents and Incidents

Cognitive system:
1. Human information processing system, including senses, perception, attention, memory, decision, action, and monitoring
2. Visual illusions
3. False hypothesis
4. Habits
5. Motivation

6. Training
7. Personality
8. Fear

Social system:

9. Social pressure
10. Role
11. Life stress

Situational system:

12. Physical stress, physical condition, state of nutrition, drugs, smoking, alcohol, fatigue, and sleep loss

Tarrel, R.J., 1985

Human Factors Associated with Runway Transgressions

Runway transgressions

1. Information transfer
   a. Pilot distraction
   b. Pilot workload
2. Awareness
   a. Complacent attitude
   b. Fatigue
3. Spatial judgment
   a. Airport markings
   b. Signs
   c. Complex configurations

Hanley, M.J., 1985

The Human Oriented Mishap Reduction (HOMR) Program

HOMR-HF database on aircraft accidents

1. Mishap data: actual, near, and nonmishap
   a. Aircraft
   b. Crew
2. System parameter date: normative data
   a. Human capabilities
   b. Aircraft capabilities

Aderet, A. and Tal, Y., 1984

Human Error in Aircraft Accidents

Behavioral Sequence model

Initial emergency
Motoric response
Recognition
Accident

Adams, J.A., 1982

Issues in Human Reliability

Task taxonomy
1. Behavioral description (what person does in system)
2. Behavioral requirements (the processes that intervene between stimulus and response)
3. Ability requirements
4. Task characteristics

Wiener, E.L., 1977

Controlled Flight into Terrain Accidents

Controlled flight into terrain
1. System failure
   a. Pilot-controller (information transfer)
   b. Noise abatement approaches
   c. Cockpit workload
   d. Crew coordination
   e. Warning devices radar
   f. Visual illusions
   g. Confusing terminology and charts.

Danaher, J.N., 1988

Human Error in ATC System Operations

ATC Errors
1. Attention
2. Judgment
3. Communications
4. Stress
5. Equipment
6. Operations
7. Management
8. Environment
9. Procedures

10. External factors

Norman, D.A., 1981

Categorization of Action Slips

Action slips
Errors of omission
Errors of commission
Errors of substitution

1. Slips that result from errors in the formation of intention
   a. Errors that are not classified as slips
   b. Mode errors: erroneous classification of the situation
   c. Description errors: ambiguous or incomplete specification of the intention
2. Slips that result from faulty activation of schemas
   a. Unintentional activation
      (1) Capture errors
      (2) Data-driven activation
      (3) Associative activation
   b. Loss of activation
      (1) Forgetting an intention
      (2) Misordering components of action sequence
      (3) Skipping steps in action sequence
      (4) Repeating steps in action sequence
3. Slips that result from faulty triggering of active schemas
   a. False triggering
      (1) Spoonerisms: reversal of event components
      (2) Blends: combinations of components from two competing schemas
      (3) Thoughts leading to actions: triggering of schemas meant only to be thought, not to govern action
      (4) Premature triggering
   b. Failure to trigger
      (1) Action preempted by competing schemas
      (2) Insufficient activation
      (3) Failure of trigger condition to match

Robinson, J.E., 1985

Classification and Determination of Aircraft Accidents (Reports Grouped into Phase of Flight Categories)

1. Preflight
2. Takeoff and climb

3. Cruise
4. Approach
5. Landing or impact
6. Maintenance and repair
7. Operation and maintenance

Subdivide each phase into—
1. Weather conditions
2. Aircraft equipment and capabilities
3. Air traffic control transactions
4. Cockpit controls and displays
5. Crew coordination
6. Unplanned pitchups and liftoffs
7. Training and experience
8. Nonstandard patterns or techniques
9. Problems in diagnosis

Salvatore, S., Huntley, S., and Mengert, P., 1985

Air Transport Pilot Involvement in General Aviation Accidents

Aircraft accidents involving ATP and PVT flying GA
1. General cause category
   a. Design
   b. Manufacturer
   c. Improper maintenance
   d. Pilot and maintenance
   e. Operational deficiency other than pilot
   f. Pilot
2. Phase of flight
   a. Approach, landing, and takeoff
   b. Cruise
   c. Acrobatics
   d. Forced landing
   e. Ground, practice, and other
3. Pilot induced
   a. Flight planning
   b. Traffic pattern errors
   c. Weather
   d. Collision
   e. Fuel system error
   f. Acrobatics
   g. Other cruise

h. Ground operations

4. Supplementary factors
   a. Weather
      (1) Weather briefing received
      (2) Weather briefing not received
      (3) Weather not briefed
   b. Mistake
   c. Unskilled in operation of aircraft
   d. Risk overconfidence
      (1) Calculated risk
      (2) Careless
      (3) Reckless
      (4) Misjudgment

Rouse, W.B. and Rouse, S.H., 1983

Proposed Human Error Classification Scheme

1. Observation of system state
   a. Excessive
   b. Misinterpreted
   c. Incorrect
   d. Incomplete
   e. Inappropriate
   f. Lack
2. Choice of hypothesis
   a. Inconsistent
   b. Unlikely
   c. Costly
   d. Irrelevant
3. Testing of hypothesis
   a. Incomplete
   b. False acceptance
   c. False rejection
   d. Lack
4. Choice of goal
   a. Incomplete
   b. Incorrect
   c. Unnecessary
   d. Lack
5. Choice of procedure
   a. Incomplete
   b. Incorrect

c. Unnecessary
d. Lack

6. Execution of procedure
   a. Step omitted
   b. Step repeated
   c. Step added
   d. Step out of sequence
   e. Inappropriate timing
   f. Incorrect discrete position
   g. Incorrect continuous range
   h. Incomplete
   i. Unrelated inappropriate action

Johnson, W.B. and Rouse, W.B., 1982

Human Errors in Troubleshooting Live Aircraft Power Plants

Maintenance error

1 Observation of system state
   a. Incomplete
   b. Misinterpreted
   c. Repeated
2. Choice of hypothesis
   a. Inconsistent with symptoms
   b. Consistent but unlikely
   c. Consistent but costly
   d. Functionally irrelevant
3. Choice of procedures
   a. Incomplete
   b. Inappropriate
   c. Lack
4. Execution of procedures
   a. Omission of steps
   b. Performed steps out of sequence
   c. Inadvertent action
5. Consequence of previous error
   a. Error was logical consequence of previous error

Van Eekhout, J.M. and Rouse, W.B., 1981

Human Error in Engine Control Room of Supertanker

1. Observation of system state

a. Incomplete
b. Inappropriate
c. Lack

2. Identification of fault
   a. Incomplete
   b. Inappropriate
   c. Lack
3. Choice of goal
   a. Incomplete
   b. Inappropriate
   c. Lack
4. Choice of procedure
   a. Incomplete
   b. Inappropriate
   c. Lack
5. Execution of procedure
   a. Incomplete
   b. Inappropriate timing
   c. Inadvertent action
6. Contributing factors
   a. Basic knowledge
   b. Controller knowledge
   c. Design inadequacies
   d. Fidelity inadequacies

Caeser, C., 1987

Flight Phase Definition

1. Takeoff
2. Climb
3. Cruise
4. Descent
5. Approach
6. Landing
7. Ground

Human Failure

1. Active failure (aware)
   a. Nonadherence to rules and SOPs
   b. Lack of discipline or vigilance
   c. Inadequate flight management

d. Short cuts
2. Passive failures (unaware)
   a. Crew misunderstanding and communications problems
   b. Complacency
   c. Forgetfulness
   d. Distraction
   e. Coordination breakdown
   f. Fatigue
   g. Boredom
   h. Lack of assistance
3. Proficiency of failures
   a. Inappropriate handling of a/c or its systems
   b. Wrong alternatives
   c. Misjudgment
   d. Lack of experience
   e. Training
   f. Competence
4. Crew incapacitation
   a. Subtle or obvious incapacitation that requires takeover
   b. Flightcrew member unable to perform due to physical inability

Boeing Commercial Airplanes, 1987

Accident Statistics

1. Phase of flight
   a. Load, taxi, and unload
   b. Takeoff
   c. Initial climb: ends at flaps up
   d. Climb
   e. Cruise
   f. Descent: from cruise to navigational fix
   g. Initial approach: includes holding pattern and continues to outer marker
   h. Final approach
   i. Landing

Edwards, E., Date and Title Unknown

Instrument Errors-Electro-Mechanical

1. Types of errors
   a. Interpretation errors
   b. Reversal errors

c. Signal interpretation errors
d. Legibility errors
e. Substitution errors
f. Using an inoperative instrument
g. Scale interpretation errors
h. Illusion errors
i. Forgetting errors

Morris, N.M. and Rouse, W.B., 1985

ERROR

Slips
Mistakes

Lautman, L.G. and Gallimore, P.L., 1987

Classification of 93 crew-caused major accidents:

1. Pilot deviated from basic operational procedures
2. Inadequate cross-check by second crew member
3. Crews not conditioned for proper response during abnormal conditions
4. Pilot did not recognize the need for go-around
5. Pilot incapacitated
6. Inadequate piloting skills
7. Pilot used improper procedure during go-around
8. Crew errors during training flights
9. Pilot not trained to respond promptly to GPWS command
10. Pilot unable to execute safe landing or go-around when runway sighting is lost below MDA or DH
11. Operational procedures did not require use of available approach aids
12. Captain inexperienced in aircraft type

Kowalsky, N.B., Masters, R.L., Stone, R.B., Babcock, G.L., and Rypka, E.W., 1974

Pilot Error-Related Aircraft Accidents

Critical condition categories
1. Experience
   a. Low pilot time in type
   b. Low copilot time in type
   c. Low pilot time in position (as captain)
   d. Low copilot time (total)

e. Other (e.g., recent experience, training, flight engineer, age differences, student pilot new, crew new, student pilot dull, and new airport)

2. Distraction
   a. Communications or traffic (excessive communications with ATC or looking out for traffic)
   b. Confusion (last minute approach change or other confusion)
   c. Hurry (close departure on same runway or other hurrying)
   d. Holding or delay
   e. Other (e.g., wake turbulence, numerous distractions, foreign student, first officer monitoring instruments, interrupted checklist, fuel burn, paperwork, poor destination weather, instructor pilot checklist, takeoff position holding, and ashtray fire)
3. Crew coordination
   a. Disagreement (disagreement on approach or configuration or other pilot calls 'off profile')
   b. Jumpseat occupant or other additional crew
   c. No required altitude callouts
   d. Pilot acting as instructor
   e. Other (e.g., loose student/instructor relationship or other interactions such as flaps without student knowing, altitude confusion, distrust first officer, thought continuing takeoff, gear up without visual verification, both pilots on controls, noncompliance, and confusion on who was flying)
4. Neglect
   a. No cross-check on ILS
   b. Improper use of checklist
   c. Improper rest/procedure
   d. Other (e.g., company did not revise checklist, other aircraft collision light off, ATC, Mach trim switch, engine reversing indicator lights, VOR out, and clearance deviation)
5. Air traffic control
   a. Delayed landing clearance
   b. Confusing radar vector
   c. Advised of traffic
   d. Poor, weak, or malfunctioning radar or radar return
   e. Other (e.g., no acknowledgement, no advisories, vector confirmation, and advisory holds)
6. "Decisions"
   a. Off acceptable profile
   b. Institutional decisions; okay to operate
   c. Copilot flying, taken over by pilot
7. Work/rest (fatigue)
   a. On duty over 8 hr
   b. Minimum rest
   c. Early morning departure
8. Machine
   a. Gross weight (overweight or heavy gross weight)
   b. Simulated engine shutoff (engine failure simulation)
   c. System failure

d. Other (e.g., simulated rudder loss, flight director oscillation, spoiler deployment and retraction, battery switch, 3 and 4 engine reverse slow spool, air noise, parking brake versus mechanical failure, and seat failure)

9. Airport
   a. Stopping problem (runway slippery, wet, slush, braking action poor, or tire residue)
   b. Touchdown problem (runway short or displaced threshold)
   c. Vertical guidance problem (no approach light, approach lights out, or localizer only)
   d. Runway hazards (upslope threshold, exposed lip or dropoff)
   e. Other (e.g., runway markings obliterated, uncontrolled airport, irregular lights, loose pavement, and hilly terrain)
10. Weather
   a. Visibility problem (heavy rain at threshold, below circling minimums, fog, snow or haze, or other visibility restrictions)
   b. Thunderstorm influencing airport or enroute weather
   c. Wind gusty
   d. Other (e.g., same route, weather above circling minimums, enroute weather, freezing drizzle, and venturi wind)

Critical decision categories

1. Decisions resulting from out-of-tolerance (off profile) conditions
   a. Takeover of controls
   b. Verbal instructions between pilots
   c. Excessive deviation called out
   d. Inadequate braking observed
   e. Assistance inflight control operation
   f. Attempt to regain directional control
   g. Go-around initiated
   h. Other
2. Decisions based on erroneous sensory inputs
   a. Approach continued visually
   b. Decided profile within limits
   c. Misleading cockpit display
   d. Misleading navigation information
   e. Runway or braking misinformation
   f. Final approach or flare profile misinformation
   g. Standard operating procedure distraction
   h. Other
3. Decisions delayed
   a. Takeover of flight controls or assistance
   b. Go-around decision
   c. Takeoff abort
   d. Thrust lever movement
   e. Other

4. Decision process biased by necessity to make destination or press on (meet schedule)
   a. Continued flight with equipment failure
   b. Altered cockpit procedures
   c. Continue with weather conditions deteriorating
   d. Runway misinformation
   e. Decision involved approach procedure
   f. Other
5. Incorrect weighting of sensory inputs or responses to a contingency
   a. Deviation from checklist or altitude callouts
   b. Icing of aircraft
   c. Disregard of cockpit displays
   d. Traffic information disregarded
   e. Disregard information on landing environment or conditions
   f. Safety degradation due to training
   g. Other
6. Incorrect choice of two alternatives based on available information
   a. Left cockpit
   b. Landed runway with unfavorable conditions
   c. Flew visual approach
   d. Other
7. Correct decision
   a. Checked approach light level
   b. Confirmed minimums
   c. Took over and flew approach
   d. Other
8. Overloaded or rushed situation for making decisions
   a. Primary attention diverted
   b. Aircraft power difficulty
   c. Observed traffic and rolled aircraft
   d. Other
9. Desperation or self-preservation decision
   a. Directional control or stopping problem
   b. Airborne loss of control
   c. Avoid ground contact
   d. Avoid other aircraft
   e. Other

Critical decisions listed as "other" in each category were miscellaneous and too few in number to list therein.

This report (Kowalsky, et al.) has an accident analysis sheet, lists their "accident characteristics and variables," and broke out "combinations of critical decisions."

Accident Characteristics and Variables

00 Number of engines
01 Time of occurrence
02 Type of accident (1st)
03 Phase of operation (1st)
04 Condition of light
05 Type weather conditions
06 Type instrument approach
07 Airport proximity
08 Airport elevation
09 Runway composition
10 Runway condition
11 Runway lighting
12 Runway length
13 Type of terrain
14 Pilots involved
15 Total flight time (1st)
16 Total flight time (2nd)
17 Hours in type (1st)
18 Hours in type (2nd)
19 Pilot age (1st)
20 Pilot age (2nd)
21 Pilot at controls
22 Sky condition
23 Ceiling
24 Visibility
25 Precipitation
26 Obstruction to vision
27 Relative wind component
28 Temperature
29 Wind velocity
30 Approach lighting availability
31 Pilot time last 24 hr (1st)
32 Pilot time last 30 days (1st)
33 Pilot time last 90 days (1st)
34 Duration of this flight (1st)
35 On duty time (1st)
36 Rest period prior to flight (1st)
37 Pilot time last 24 hr (2nd)
38 Pilot time last 24 hr (FE)
39 Pilot time last 30 days (2nd)
40 Pilot time last 30 days (FE)

41 Pilot time last 90 days (2nd)
42 Pilot time last 90 days (FE)
43 Duration of this flight (2nd)
44 Duration of this flight (FE)
45 On duty time (2nd)
46 On duty time (FE)
47 Rest period prior to flight (2nd)
48 Rest period prior to flight (FE)

Billings, C.E. and Chaeney, E.S., 1981

Information Transfer Problems

Classification
1. Instructions
   a. Message origin
      (1) Controller
      (2) Some other device
   b. Message type
      (1) Clearance
      (2) Coordination
      (3) Request
      (4) Warning
      (5) Other control
      (6) Statement of intentions
      (7) Data
      (8) Advisory
      (9) Confirmation
   c. Message problems
      (1) Absent
      (2) Incomplete
      (3) Inaccurate due to phonetic similarity
      (4) Transposition
      (5) False
      (6) Ambiguous
      (7) Untimely
      (8) Garbled in transmission or presentation
      (9) Not transmitted because of device failure
      (10) Not received due to failure to monitor by intended recipient
   d. Message medium
      (1) Publication
      (2) Radio
      (3) Interphone

(4) Video
(5) Tape recording
(6) Chart or similar graphic
(7) Telephone
(8) Direct voice
(9) Visual (instrument, etc.)

2. Errors involving briefing of relief controllers
   a. Absent briefing
   b. Incomplete briefing
   c. Inaccurate briefing
   d. Associated factors
      (1) Nonrecall of pertinent information
      (2) Failure of technique
      (3) Failure of perception
      (4) Complacency
      (5) Distraction
      (6) Message ambiguity
      (7) Workload
      (8) Inattention
      (9) Misidentification of aircraft
      (10) Other factors
3. Human errors associated with coordination failures
   a. Human errors
      (1) Nonrecall
      (2) Technique errors
      (3) Perceptual errors
      (4) Failure to monitor
      (5) Message inaccuracy
      (6) Misidentification
   b. Predisposing factors
      (1) Distraction
      (2) Excess workload
      (3) Experience and training level
      (4) Complacency
      (5) Airspace configuration
      (6) Procedural problem
      (7) Automation mindset
      (8) Equipment failure
      (9) Interpersonal relationship

Prendal, B., 1987

Categorization of Failures:

Active failures: Nonadherence to rules, standards, and procedures, lack of resource management, gross lack of appropriate vigilance or discipline, and laziness.
Passive failures: Complacency, forgetfulness, boredom, low arousal level, coordination breakdown, distraction,misunderstanding, communication problems, lack of assistance, and high workload.
Proficiency failure: Inappropriate handling of aircraft and its systems, misjudgment, and wrong decision (lack of experience, training, and competence).
Incapacitation: Flightcrew member unable to perform his/her duty due to physical inability.

Becker-Lausen, E., Norman, S., and Pariante, G., 1987

Cockpit Crew Cause Factors, from Boeing Report, 1983

Judgment and technique
Variance from established procedures or regulations
Navigational error position or altitude
Improper system operation
Improper flight control operation
Failure to heed weather precautions
Failure to see and avoid midair collisions

Significant Accident Causes and Their Percentage of Presence in 93 Major Accidents from Sears, 1986

Pilot deviated from basic operational procedures (33%)
Inadequate cross check by second crew member (26%)
Design faults (13%)
Maintenance and inspection deficiencies (12%)
Complete absence of approach guidance (10%)
Captain did not respond to crew inputs (10%)
ATC failures or errors (9%)
Crews not conditioned for proper response during abnormal conditions (9%)
Other (9%)
Weather information insufficient or in error (8%)
Runway hazards (7%)
ATC/crew communication deficiencies (6%)
Pilot did not recognize the need for go-around (6%)
No GPWS installed (5%)
Weight or center of gravity in error (5%)
Deficiencies in accepted navigation procedures (4%)

Pilot incapacitation (4%)
Inadequate piloting skills (4%)
Pilot used improper procedure during go-around (3%)
Crew errors during training flights (3%)
Pilot not trained to respond promptly to GPWS command (3%)
Pilot unable to execute safe landing or go-around when runway sighting is lost below MDA or DH (3%)
Operational procedures did not require use of available approach aids (3%)
Captain inexperienced on aircraft type (3%)

United Airlines Proposed Classification Scheme by Simmons, 1987

1. Receipt and dispatch incident: Ground workers hit by aircraft—about 4 to 8 fatalities per year happen between brake release and taxi or taxi and park
2. Runway incursion: Turning down the wrong runway; e.g., Tenerife
3. Other ground damage
4. Minimum terrain separation: Too close to ground on landing/approach; landing in water, etc.
5. Altitude deviation
6. Navigation deviation: Left or right of route; e.g., Korean Airlines
7. Midair collision: e.g., PSA, San Diego
8. Weather-related injury damage: Icing, wind shear; e.g., Air Florida
9. Unstabilized approach: Unsteady parameters on approach
10. Landing on wrong runway or wrong airport: e.g., Delta
11. Other procedural problems: behavioral problems, "Cowboy Flying," significant deviation from SOP
12. Runway excursions: Running off end or side of runway or landing too short

British Army Air Corps Proposed Classification Scheme by Feggetter, 1985

Database No.

1	Aircraft details
2	Location of accident
3	Mechanical report
4	Biographical details of crew
5	Personal history of aircrew
6	Aircrew selection tests
7	Initial training records of aircrew
8	Continuation training records of crew
9	Details of previous week's activities
10	Details of previous night's activities
11	Details of activities on the accident day
12	Life stress
13	Life stress
14	Purpose of sortie
15	Supervisory details

16 Meteorological forecast
17 Meteorological conditions according to aircrew
18 Meteorological aftercast
19 Witness accounts of the accident
20 Pilot's account of the accident
21 Board of Inquiry's account of the accident
22 Injuries sustained
23 Aircrew's flying hours
24 Status of aircrew
25 Personality assessment
26 Aircrew's information processing system
27 Cause factors cognitive
28 Cause factors social
29 Cause factors situational
30 Human factors recommendations
31 Board on Inquiry's recommendations

Diehl, A.E., Hwoschinsky, P.V., Livack, G.S., and Lawton, R.S., 1987

Top 10 Causes for All Fixed Wing Aircraft Accidents-1982-NTSB

1. Pilot—failed to maintain directional control
2. Undetermined
3. Pilot—failed to maintain airspeed
4. Pilot—misjudged distance
5. Fuel exhaustion
6. Pilot—inadequate preflight preparation and/or planning
7. Pilot—selected unsuitable terrain
8. Pilot—inadequate aircraft preflight
9. Pilot—inadequate visual lookout
10. Pilot—misjudged airspeed

SAE, 1987

Managing Human Performance—Institute of Nuclear Power Operations Human Performance Evaluation System

1. Behavioral aspects of sensing and mental processing
   a. Failure to detect the error
   b. Adverse environmental condition
   c. Self-checking/verification inadequate
   d. Not familiar/well practiced
   e. Misinterpretation or misdiagnosis

f. Insufficient time to take action
g. Following a procedure incorrectly
h. Cognitive overload
i. Distractions or interruptions
j. Lapse of memory
k. Mental or physical fatigue or sickness
l. Overconfidence or complacency
m. Boring or repetitious task

2. Error evoked by sensing and mental process problems
   a. Omission
   b. Transposition
   c. Quantitative
   d. Miscommunication
   e. Extraneous act
   f. Untimely act
   g. Out of sequence

3. Verbal and written communications
   a. Failure to transmit information
   b. Lack of or failure to use established communications procedures
   c. Information transmitted but not received
   d. Inaccurate messages
   e. Time constraints
   f. Noise
   g. Glare
   h. Inadequate of malfunctioning communications equipment

4. Defects in training content and methods
   a. Insufficient practice and hands-on experience
   b. Inadequate course content
   c. Insufficient refresher training
   d. No training provided
   e. Use of informal or unstructured on-the-job training methods
   f. Insufficient specific system or component training
   g. Lack of training on the potential consequences or error and how to verify proper task completion
   h. Inadequate training on procedures or references used to guide task performance

5. Work place environment
   a. Distractions
   b. Inadequate installed lighting
   c. Uncomfortable temperature or humidity
   d. Improperly fitted or selected protective clothing

e. Selected type of respiratory equipment
f. Poorly identified components such as electrical terminations, electronic circuit boards, cabinets, controls, and valves

Harwood, K., 1986

Error Categories

1. Flightcrew errors
2. ATC communication errors
3. Navigation facility errors
4. Aircraft problems
5. Airport facility problems
6. Weather and terrain obstruction problems
7. Problems with charts, published procedures, and publications

Bureau of Air Safety Investigation

Human Factors Guide for the Conduct of Aircraft Accident Investigation

1. Anthropometrics
   a. Give height of the pilot in centimeters
   b. Give weight of the pilot in kilograms
   c. Describe the build of the pilot (select one)
      (1) Slender
      (2) Average
      (3) Muscular
      (4) Heavy
      (5) Obese
   d. Could any of the following dimensions have been a factor in the cause of this accident?
      (1) Sitting height
      (2) Functional reach
      (3) Leg length
      (4) Shoulder width
      (5) Height
      (6) Weight
      (7) Build
2. Physical condition
   a. Describe the physical condition of the pilot (select one)
      (1) Sedentary
      (2) Average
      (3) Athletic
   b. Could the physical condition of the pilot have been a factor in the cause of this accident?

3. Physical strength
   a. Describe the relative strength of the pilot for his/her age and body type (select one)
      (1) Frail
      (2) Below average
      (3) Average
      (4) Above average
      (5) Strong
   b. Could the physical strength of the pilot have been a factor in the cause of this accident?
4. Physical fatigue
   a. Was the pilot physically fatigued at the time of the accident?
   b. Physical fatigue was due to— (select one)
      (1) Prolonged physical activity
      (2) Brief but extreme physical activity
      (3) Both prolonged and extreme physical activity
5. Physical task saturation
   a. Was the pilot physically task saturated at the time of the accident?
   b. Physical task saturation was due to—(select one)
      (1) The difficulty of the task exceeded the pilot's physical capacity to perform it
      (2) The number of necessary tasks exceeded the pilot's physical capacity to perform all of them
      (3) Both the number and difficulty of tasks exceeded the pilot's physical capacity to perform them
6. Physical coordination
   a. Describe the relative motor skill ability of the pilot (select one)
      (1) Awkward
      (2) Below average coordination
      (3) Average coordination
      (4) Above average coordination
      (5) Agile
   b. Could the physical coordination of the pilot have been a factor in the cause of this accident?

Physiological Variables

1. Illusions—If applicable, indicate the type of illusion experienced in the course of the accident sequence of events
   a. Vestibular
      (1) Somatogyral illusion
      (2) Somatogravic illusion
      (3) The leans
      (4) Coriolis illusion
      (5) Elevator illusion
      (6) Giant hand illusion
   b. Visual
      (1) Autokinesis

(2) Horizontal misplacement
(3) Circularvection
(4) Linearvection
(5) Landing illusions
(6) Chain-link-fence illusion
(7) Flicker vertigo
(8) Geometric perspective illusion

2. Other factors to be considered in dealing with illusions
   a. Previous history
   b. Previous training
   c. Type of training
3. Vision, hearing, and smell—For the sense of vision, hearing and smell, characterize visual, auditory and olfactory stimuli by one of the following, if applicable:
   a. Subthreshold
   b. Detectable but not interpretable
   c. Detectable but distracting or incapacitating
   d. Detectable but not processable along with other stimuli
   e. Detectable
4. Vision
   a. Visual acuity—Was the requirement to distinguish different parts and to resolve fine details in the environment beyond normal limits of visual acuity?
   b. Focus time—Was there sufficient time within the accident sequence of events for the pilot to change focus distance from one significant visual cue to another?
   c. Light adaptation—Was the pilot adapted to the light intensity level that was required to perform the accident task?
   d. Speed perception—Was the pilot able to judge accurately his rate of movement or that of another significant object, by outside visual cues?
   e. Depth perception—Was the pilot able to accurately judge his/her distance from another significant object, including the ground, by outside visual cues?
   f. Empty field myopia—Was the pilot's visual field essentially void of significant objects on which to focus?
   g. Waiver—Was the pilot on waiver for vision?
   h. Did the pilot wear glasses? (select one)
      (1) The pilot did not wear glasses
      (2) The pilot wore glasses but not while flying
      (3) The pilot wore glasses while flying
   i. Did the pilot have a current prescription for his glasses?
   j. Did the pilot wear contact lens?
   k. Was the pilot wearing glasses or contact lenses at the time of the accident?
   l. Should he/she have been?
5. Reaction time
   a. Was there sufficient time for the pilot to detect and process significant environmental cues?
   b. Was there sufficient time to make a appropriate decision?

c. Was there sufficient time to take the appropriate action?

6. Nutritional factors
   a. Did the food and water intake of the pilot, within 24 hr prior to the accident, meet recommended nutritional standards?
   b. How many hours were there between the pilot's last full meal or snack and the accident?
   c. Had the pilot consumed food within 6 hr of the accident flight which is known to produce gastro-intestinal discomfort?
   d. Had the pilot experienced a recent (last 30 days) significant (>5%) weight loss?
   e. Was the pilot on a weight control or other prescribed diet at the time of the accident?
   f. Indicate the type of weight control or other prescribed diet he/she was on (select one)
      (1) None
      (2) High carbohydrate, low protein, low fat (Pritikin)
      (3) High protein, low carbohydrate, low fat (Scarsdale)
      (4) High protein, high fat (Atkins, Stillman)
      (5) Starvation
      (6) General reduction in calorie intake
      (7) Other
   g. Based on the pilot's physical activity level, ambient conditions, and fluid intake in the past 24 hr, indicate his or her probable level of dehydration (select one)
      (1) Not dehydrated
      (2) Mildly dehydrated
      (3) Moderately dehydrated
      (4) Severely dehydrated

7. Circadian rhythm
   a. How many time zones did the pilot cross within the 48 hr preceding the accident?
   b. Was the accident flight the first night flight after a series of day flights or no flying activity?
   c. Was the accident flight the first day flight after a series of several night flights?
   d. Was the accident flight preceded by several days of irregular waking or sleeping schedules?

8. Acute/transient fatigue
   a. How many hours of uninterrupted sleep did the pilot get in his/her last regular sleep period prior to the accident flight?
   b. How many hours elapsed between his/her last regular sleep period and the time of accident occurrence?
   c. Did the pilot have a nap between his/her last regular sleep period and the accident flight?
   d. What was the duration of the nap between his/her last regular sleep period and the accident flight?
   e. At what level would you place the activity engaged in by the pilot between the last sleep period and the accident flight (select one)
      (1) Low physical or mental activity
      (2) Moderate physical or mental activity—brief period
      (3) Moderate physical or mental activity—prolonged period
      (4) Extreme physical or mental activity
   f. Of what duration was the pilot's usual regular sleep period in hours?

g. Was the regular sleep period of the pilot prior to the accident flight interrupted?
h. What was the scheduled duration of the accident flight?
j. How long (in minutes or hours) into the flight did the accident occur?

9. Cumulative/chronic fatigue
   a. Indicate the number of duty hours performed by the pilot in the 7-day period prior to the accident
   b. Indicate the total number of hours the pilot slept in the 7-day period prior to the accident
   c. Indicate the number of days since the pilot's last leave period
   d. What was the duration of the pilot's last leave period?
   e. What was the primary activity during the pilot's last leave period? (select one)
      (1) Traveling vacation (sightseeing, skiing, etc.)
      (2) Visiting relatives
      (3) Working at home
      (4) Relaxing at home
      (5) Other (specify)
   f. Indicate the mode of travel while on leave, if recent— (select one or more)
      (1) Local travel only
      (2) Commercial air standby
      (3) Commercial air
      (4) Private auto
      (5) No travel
      (6) Other (specify)
10. Skill fatigue
   a. For this particular pilot, did the accident flight demand sustained concentration and a high degree of skill (e.g., agricultural, mustering, single pilot IRF, and low level operations)?
   b. How long had the pilot been flying under these high mental workload conditions prior to the accident?
   c. Had the pilot been flying similar high workload operations in the 24 hr preceding the accident flight? (give details)
11. Hypoxia
   a. Did the pilot show any signs of hypoxia prior to or during the accident sequence of events?
   b. Indicate the type of hypoxia experienced (select one)
      (1) None
      (2) Stagnant
      (3) Hypemic
      (4) Hypoxic
      (5) Histoxic
12. Hyperventilation—Did the pilot show any signs of hyperventilation prior to or during the accident sequence of events?
13. Acceleration
   a. Did the pilot have a history of low tolerance to "G"?
   b. How long had it been prior to the accident flight since the pilot was exposed to high "G"?
   c. Indicate any acceleration effect the pilot experienced during the accident sequence of events
      (1) Gray out

(2) Blackout
(3) Loss of consciousness
(4) Restricted movement due to high "G"
(5) None

d. Did the pilot experience more than 3 "Gs" during the accident maneuver?

14. Decompression sickness
    a. Did the pilot experience any type of decompression sickness during the accident flight?
    b. Indicate the type of decompression sickness experienced during the accident flight (select one)
        (1) Bends
        (2) Chokes
        (3) Neurological manifestations
    d. At what altitude was the flight conducted?
    e. What was the pressurization schedule in the cockpit?
    f. How long did he/she remain at maximum altitude?
15. Trapped gas effects
    a. Did the pilot experience any trapped gas effects in the course of the accident flight?
    b. Any surgery or dental care in recent past?
    c. Indicate the type of trapped gas effects experienced (select one or more)
        (1) Gastrointestinal gas expansion
        (2) Ear block
        (3) Sinus block
        (4) Tooth pain
    d. Had the pilot received formal training in trapped gas effects within the last 6 to 12 months?
16. Motion sickness
    a. Did the pilot have a history of motion sickness?
    b. Did the pilot experience motion sickness prior to or during the accident sequence of events?
    c. Was the female pilot pregnant?
    d. If the pilot is female, what stage was she in, in her menstrual cycle? (select one)
        (1) Within one week prior
        (2) During
        (3) Other

Psychological Variables

1. General adaptation
    a. What was the emotional state of the pilot prior to the accident flight? (select one or more)
        (1) Apprehensive
        (2) Confused
        (3) Panicked
        (4) Angry
        (5) Frustrated
        (6) Happy
        (7) Sad

(8) Confident
(9) Depressed
(10) Cynical
(11) Unremarkable
(12) Other

b. What was the emotional state of the pilot during and at the point of the accident flight? (select one or more)
(1) Apprehensive
(2) Confused
(3) Panicked
(4) Angry
(5) Frustrated
(6) Happy
(7) Sad
(8) Confident
(9) Depressed
(10) Cynical
(11) Unremarkable
(12) Other

c. Was an intense emotional state at the time of the accident the result of— (select one or more)
(1) An inflight emergency
(2) An inflight contingency
(3) Routine flight demands
(4) Realization of impending disaster
(5) Nonflight related
(6) Other (no intense emotional state)

2. Information processing—Within the course of the accident sequence, indicate which of the following occurred
a. Nonperception
b. Misperception
c. Delayed perception
d. Delayed decision
e. Poor decision
f. Delayed response
g. Poor response
h. Cognitive task saturation
i. Cognitive disorientation (loss of situational awareness)
j. None
k. Other (specify)

3. Attention level
a. Indicate the level of task involvement of the pilot in the action (or lack of action) that sustained the accident sequence
(1) Focused attention

(2) Peripheral attention
(3) Automatic performing of procedures
(4) None

b. Was the task that the pilot was performing appropriate at the time of the accident?
c. Which of the following occurred in the accident sequence of events?
(1) General inattention
(2) Selective inattention
(3) Channelized attention
(4) Fascination
(5) External distraction
(6) Internal distraction
(7) Habit pattern interference
(8) Habit pattern substitution
(9) Boredom
(10) Complacency
(11) Inappropriate response
(12) Expectation or inappropriate perceptual set
(13) None

4. Moods
a. Did the pilot have a history of sudden or unexplained mood changes?
b. Did the pilot's mood change noticeably prior to the accident flight?
c. Did the date of the accident in terms of day and month correspond with the death of any person considered to be a "significant other" to the pilot (e.g., parent, sibling, spouse, or child)
d. Did the pilot's mood change noticeably during the accident flight?
5. Personality—Describe the pilot's personality in terms of his or her typical behavior along the continuum between the following 16 opposite traits. Assume that a "normal" or "stable" person will always score a 4 on the 7 point scale.

This personality profile is part of an empirically proven personality test called the "16 personality factor test." The words listed in uppercase letters are the main personality traits, while the words in lowercase letters describe what the creator of the test means by using a particular trait.

RESERVED, detached, critical, cool	1 2 3 4 5 6 7	OUTGOING, warmhearted, easy-going, participating
LESS INTELLIGENT, concrete thinking	1 2 3 4 5 6 7	MORE INTELLIGENT, abstract thinking, bright
AFFECTED BY FEELINGS emotionally less stable, easily upset	1 2 3 4 5 6 7	EMOTIONALLY STABLE, faces reality, calm, mature

HUMBLE, mild, conforming, accommodating	1 2 3 4 5 6 7	ASSERTIVE, independent, aggressive, stubborn
SOBER, prudent, serious, taciturn	1 2 3 4 5 6 7	HAPPY-GO-LUCKY, impulsive, lively, enthusiastic
EXPEDIENT, evades rules feels few obligations	1 2 3 4 5 6 7	CONSCIENTIOUS, persevering staid, rule-bound
SHY, restrained diffident, timid	1 2 3 4 5 6 7	VENTURESOME, socially bold, uninhibited, spontaneous
TOUGH-MINDED, self-reliant, realistic, no-nonsense	1 2 3 4 5 6 7	TENDER-MINDED, dependent, over-protected, sensitive
TRUSTING, adaptable free of jealousy, easy to get on with	1 2 3 4 5 6 7	SUSPICIOUS, self-opinionated, hard to fool
PRACTICAL, careful, proper, conventional	1 2 3 4 5 6 7	IMAGINATIVE, wrapped up in inner urgencies, careless of practical matters
FORTHRIGHT, natural artless, sentimental	1 2 3 4 5 6 7	SHREWD, calculating, worldly, penetrating
PLACID, self assured confident, serene	1 2 3 4 5 6 7	APPREHENSIVE, worrying depressive, troubled
CONSERVATIVE, respecting established ideas, traditional	1 2 3 4 5 6 7	EXPERIMENTING, critical, liberal, analytical, free thinking
GROUP-DEPENDENT, a joiner and sound follower	1 2 3 4 5 6 7	SELF-SUFFICIENT, prefers own decisions, resourceful

UNDISCIPLINED, SELF CONFLICT, follows own urges, careless of protocol	1 2 3 4 5 6 7	CONTROLLED, socially precise, following self image
RELAXED, tranquil, torpid, unfrustrated	1 2 3 4 5 6 7	TENSE, frustrated, driven overwrought

Psycho-Social Variables

1. Professional variables
   a. Describe the primary duty of the pilot
   b. Describe any additional duties of the pilot
   c. Did the pilot participate in formulating company policies or procedures?
   d. Was the pilot characteristically sensitive to supervisory or peer pressure?
   e. With whom did the pilot most often socialize?
   f. Was the pilot satisfied with his/her choice of career?
   g. Was the pilot satisfied with his/her career progression?
   h. Did the pilot violate rules, regulations, or established procedures in the course of the accident sequence of events?
   i. Indicate the reason for the violation of any rules, regulations, or established procedures (select one)
      (1) Did not violate rules
      (2) Pilot did not know them
      (3) Pilot perceived that they did not apply to his or her
      (4) Pilot perceived he/she could best accomplish the flight by violating them
      (5) Pilot did not agree with them
      (6) Other (specify)
   j. Indicate the pilot's reason for wanting to be a pilot (if known)
      (1) Love of flying
      (2) Family expectations
      (3) Financial considerations
      (4) Image
      (5) Other (specify)
2. Familial factors:
   a. Was the pilot having significant interpersonal problems with any of the following?
      (1) Spouse
      (2) Girl/boy friend
      (3) Children
      (4) Parents
      (5) Other
   b. Were any of the foregoing suffering from a serious illness at the time of the accident?

c. Indicate the degree to which personal problems usually affected the pilot's performance (select one)
   (1) None
   (2) Mildly
   (3) Moderately
   (4) Significantly
d. Had any of the foregoing recently (last 12 months) died?

3. Motivation
   a. Indicate the type of motivation of the pilot to achieve the objective or complete the flight during the accident sequence of events (select one)
      (1) Constructive motivation
      (2) Misplaced motivation
      (3) Excessive motivation
      (4) Undermotivation
   b. Indicate the source of the pilot's motivation to achieve the objective or complete the flight
      (1) Prestige/power
      (2) Peer respect/affection
      (3) Safety/security
      (4) Survival
      (5) Other (specify)
4. Financial factors
   a. Had the pilot's financial obligations recently changed significantly or were about to change significantly (e.g., new home or new car)?
   b. Had the pilot recently incurred a significant financial loss or gain?
   c. Was the pilot involved in, or about to be involved in, any legal action that may have threatened his/her security?
5. Habit patterns
   a. Indicate the number of packs of cigarettes the pilot smoked daily
   b. Indicate the number of drinks containing alcohol the pilot usually consumed daily
   c. Indicate the number of drinks containing alcohol the pilot consumed within 24 hr prior to the accident flight
   d. Indicate any of the following pilot's habits that had changed in the past 30 days
      (1) Drinking
      (2) Smoking
      (3) Eating
      (4) Sleeping
      (5) Socializing
      (6) Recreational
      (7) Work related
      (8) None
      (9) Other (specify)
   e. What type of vehicle does the pilot drive?

Pathological Variables

1. Drugs
   a. Was the pilot using any drugs whose intended or unintended effects were present at the time of the accident?
   b. Indicate the purpose of the drugs (select one of the following)
      (1) Treatment of disease or illness (colds, flu, etc.)
      (2) Prevention of disease
      (3) Weight management
      (4) Mood alteration
      (5) Birth control
      (6) Sleep control
      (7) Other
   c. Indicate the source of the drugs (select one)
      (1) Over the counter
      (2) Prescribed
      (3) Borrowed
      (4) Other (specify)
2. Organic pathology
   a. Was the pilot suffering from any disease or trauma at the time of the accident that may have reduced his/her performance ability, either directly or by preoccupation with the symptoms?
   b. Did the pilot have any recent (30 days) episodes of fainting?
   c. Did the pilot's parents have a history of heart disease, stroke, or epilepsy?
3. Functional pathology
   a. Did the pilot ever demonstrate suicidal tendencies?
   b. Was the pilot suffering from subjective fatigue?
   c. Was the pilot's behavior significantly different than usual prior to the accident flight?
   d. Was the pilot chronically depressed prior to the accident flight?

Selection, Training, and Experience

1. Flight experience other than civil pilot (in hours)
   a. None
   b. Armed forces
   c. Overseas
   d. Other (specify)
2. Current phase of training in applicable
3. Indicate any problem areas in training
   a. None
   b. Aircraft control
   c. Academics
   d. Anxiety or depression
   e. Airsickness

f. Disorientation
g. Other (specify)

4. Undergraduate pilot's training class standing?
5. Time since last altitude chamber training
   a. Never accomplished
   b. <6 months
   c. 6 months - 1 year
   d. 1 - 2 years
   e. 3 - 4 years
   f. > 4 years
6. Time since last spatial disorientation training received
   a. Never accomplished
   b. <6 months
   c. 6 months - 1 year
   d. 1 - 2 years
   e. 3 - 4 years
   f. >4 years
7. Type of most recent spatial disorientation training received
   a. Academic only
   b. Barany chair
   c. Vertigon
   d. Motion simulator
   e. Inflight demonstration
   f. Other (specify)
8. Currency—indicate any of the following in which the pilot was not current at the time of the accident, if relevant:
   a. None
   b. Landing (day or night)
   c. Nonprecision approach
   d. Precision approach
   e. Sortie (day or night)
   f. Low level
   g. Other (specify)
9. Time since accident maneuver was last performed
   a. Never performed prior to accident
   b. <1 week
   c. 1 - 2 weeks
   d. 3 - 4 weeks
   e. 1 - 2 months
   f. >2 months
10. Describe upgrade training if applicable
11. Time since pilot's last instrument checkride
   a. <1 month

b. 1 - 6 months
c. 7 - 12 months
d. > 12 months
e. Accident sortie was an instrument checkride

12. Type of other aircraft the pilot was current in at time of accident
    a. None
    b. Single engine
    c. Multiengine
    d. Glider
    e. Helicopter
    f. Other
13. Indicate the pilot's total flying time
14. Indicate the pilot's total time in the accident aircraft
15. Indicate the number of hours flown in the last 30 days, 60 days, and 90 days
16. Indicate the number of hours the pilot flew in the last 48 hr as a crewmember
17. Indicate the number of flights flown in the last 30 days, 60 days, and 90 days
18. Had the pilot ever performed the accident maneuver before?
19. Had the pilot performed the accident maneuver before, but not within the last 30 days?
20. How much of the duty day had elapsed at the time of the accident?
21. How many flight hours had the pilot flown in that duty day?
22. What was the number of flights flown in the crew duty day of the accident?
23. Had the pilot ever had an accident before? If yes, what were the circumstances behind the accident(s)?
24. The pilot's last reportable incident (describe if relevant)

Command and Control

This category addresses the adequacy of both the supervision and guidance provided to and/or by the pilot. Guidance may be in the form of briefings, regulations, operating instructions, etc., designed to assist the pilot in performing the flight. Supervision includes all levels of command involved with the authority and responsibility to make the decision relevant to the accident sequence of events and extends all the way from company policy down to crew/flight coordination. Of particular importance is the owner/operator's responsibility to ensure that the pilot is qualified to undertake the proposed flight (ANO40.1.0.6.1.4.(d)).

1. The person with the authority to make the decision and/or responsible for making decisions relevant to the accident flight was—
    a. Timely and at the appropriate level
    b. Made at too low a level to have sufficient information
    c. Made at too high a level to have sufficient information
    d. Not timely because of level at which decision was made
    e. Other (specify)
2. Decision made relevant to the accident sequence of events were—

a. Clearly defined and accessible
b. Not clearly defined
c. Not readily accessible
d. Other (specify)

3. Supervision during the accident flight by other than the flightcrew was—
   a. Not required
   b. Required to coordinate with other agencies
   c. Required for continuing guidance
   d. Required due to crew inexperience
   e. Other (specify)
4. Supervision of the accident flight by other than the flight crew was—
   a. Adequately provided
   b. Not adequately provided
   c. Excessively provided
   d. Other (specify)
5. Technical orders, checklist(s), regulations, operating instructions, instrument departure and approach plate(s), area charts/maps, etc., were—
   a. Adequate and available
   b. Incomplete (not sufficient and/or timely) or noncurrent
   c. Misleading or confusing
   d. Not adequately available
   e. Other (specify)
6. Cockpit duties were—
   a. Clearly defined and integrated
   b. Not clearly defined
   c. Not effectively integrated among crewmembers (weighted too heavily on one or more members)
   d. Other (specify)
7. Crewmember effectiveness in adhering to assigned duties
   a. It was clear who was in command of the aircraft
   b. It was not clear who was in command of aircraft
   c. All crewmembers performed their assigned duties
   d. Individual duties were abandoned to assist other crewmember
   e. Other (specify)
8. Pilot violations; regulations were—
   a. Not violated by the pilot
   b. Violated, but unintentionally
   c. Violated intentionally
   d. Violated with the knowledge and consent of supervisors
   e. Violated without the knowledge and consent of supervisors
   f. Violated with knowledge and consent of peers
   g. Violated without knowledge and consent of peers
   h. Other (specify)
9. Supervisor violations; regulations were—

a. Not violated by the supervisor
b. Violated, but unintentionally
c. Violated intentionally
d. Violated with the knowledge and consent of pilot(s)
e. Violated without the knowledge and consent of pilot(s)
f. Other (specify)

10. Violation precedents; regulations were—
a. Never previously violated in company
b. Seldom violated in company
c. Sometimes violated in company
d. Often violated and it was general knowledge in company
e. Other (specify)

11. Apparent reason for violation was—
a. Lack of knowledge of applicable rule(s)
b. Lack of time to follow rule(s)
c. Perception that rule(s) did not apply to this situation
d. Perception that rule(s) did not apply to the pilot
e. Mission could not be completed if rule(s) strictly adhered to
f. Other (specify)

12. Operational rules, training rules, and maintenance rules
a. No operational, training, or maintenance rules were waived
b. Operational, training, or maintenance rules were waived
c. Other (specify)

13. Medical standards (including crew rest, medication, etc.)
a. No medical standards were waived
b. Medical standards were waived
c. Other (specify)

14. Supervisor's role in flight planning
a. Considered all significant factors
b. Some significant factors not considered
c. Did not participate in flight planning
d. Other (specify)

15. Pilot's role in flight planning
a. Considered all significant factors
b. Omitted some significant factors
c. Did not formally plan flight
d. Other

16. Flight briefing was—
a. Thoroughly briefed to all participants
b. Not briefed to supervisors
c. Not briefed to all participating crewmembers
d. Different from flight flown
e. Other (specify)

17. Controlling agency—indicate if any of the following were in a position to provide supervision, guidance, and/or support to the pilot during the accident sequence of events
    a. Tower
    b. Ground control
    c. Air route traffic control center
    d. Departure/approach control
    e. Runway supervisory officer
    f. Owner/operator
    g. Other member of the flight
    h. Other aircraft
    j. Other (specify)

Operational Requirements

1. Flight type—describe
2. Flight urgency—relative importance, real or perceived, placed on flight by the pilot
    a. Routine
    b. Special
3. Maneuver type—indicate the basic flight maneuver that was being performed at the time of the accident
    a. Taxi
    b. Takeoff
    c. Climbout
    d. Cruise
    e. Penetration and descent
    f. Approach
    g. Go around or missed approach
    h. Landing
    j. Other (specify)
4. Tactics employed were—
    a. Authorized or unauthorized
    b. Familiar or unfamiliar
    c. Appropriate or inappropriate
    d. Other (specify)
5. Time constraints—factors that might have resulted in the pilot feeling rushed
    a. None
    b. Delay in takeoff
    c. Anticipated bad weather
    d. Flight demands or constraints
    e. Return home from absence or cross country, etc.
    f. VIP flight
    g. Press-on-itis
    h. Other (specify)

6. Operating location
   a. Deployed
   b. Home base
   c. Familiar area (not home base)
   d. Unfamiliar area
   e. Other (specify)
7. Availability of resources—constraints imposed by short supply, nonavailability, or acquisition delays
   a. None
   b. Aircraft
   c. Fuel, oil, or water
   d. Parts
   e. Personnel
   f. Other (specify)

Support Agencies

Indicate the role of each of the following in contributing to or sustaining the accident sequence of events.

1. Other crewmembers: personnel; airfield maintenance personnel, weather services, air route traffic controller, approach and departure controller, medical support personnel, and supply personnel
   a. Did not enter into accident sequence of events
   b. Caused high workload
   c. Did not perform assigned or delegated duties
   d. Provided inadequate or misleading information
   e. Created high accident potential
   f. Caused delays
   g. Other (specify)

2. Aircraft designers, maneuver designers, life support equipment designers, and personal equipment designers
   a. Did not contribute to accident sequence of events
   b. Caused high workload
   c. Overlooked human engineering considerations
   d. Created high accident potential
   e. Other (specify)

3. Aircraft manufacturer, life support equipment manufacturers, and personal equipment manufacturers
   a. Did not contribute to accident sequence of events
   b. Caused high workload
   c. Material defect or deficiencies not detected
   d. Created high accident potential
   e. Other (specify)

Morale Considerations

Factors within the operational environment or organizational climate of the company that might influence the pilot's motivation or behavior.

1. Pilot was in the past 1-year passed over for promotion
2. Pilot designated for, considered for, or about to be considered for—
   a. None
   b. Promotion
   c. Upgrade
   d. Conversion
   e. Other (specify)

3. Was the pilot at the duty location and/or base of his choice?
4. How many years until the pilot was eligible for retirement?
5. Duty satisfaction—based on peer perception or on self-report, how would the pilot rate the following aspects of his duties on a scale of 1 to 5 (1 is a low/unfavorable rating and 5 a high/favorable rating).

Challenge	1 2 3 4 5
Recognition	1 2 3 4 5
Fulfillment	1 2 3 4 5
Additional duties	1 2 3 4 5
Absences from home	1 2 3 4 5
Standby	1 2 3 4 5
Time off	1 2 3 4 5
Pay compared to rest of industry	1 2 3 4 5
Advancement opportunity	1 2 3 4 5
Flying frequency	1 2 3 4 5
Job satisfaction	1 2 3 4 5

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Personnel Information

Pilot at controls
a. Pilot in command
b. Copilot
c. Student
d. Supervisory pilot
e. None
f. Both pilots
g. Instructor
y. Other
z. Unknown

Pilot in command and copilot
Age
In years
z. Unknown

License
Airplane
A - Student pilot
B - Private pilot
C - Commercial pilot
5 - Senior commercial pilot
D - Airline transport pilot
Helicopter
V - Private pilot
W - Commercial pilot
X - Airline transport pilot

T - Glider pilot
U - Free balloon pilot
Y - Other
I - None (not issued or expired)
Z - Unknown

Class ratings (select up to two items)
Airplane
A - Single-engine, land
B - Multiengine, land
C - Single-engine, sea
D - Multiengine, sea
Helicopter
1 - Single-rotor
2 - Multirotor

3 - Gyroplane
9 - Other, helicopter
Y - Other, airplane
X - None

Type rating
Y - Possessed required rating
X - Did not possess required rating
W - Rating not required
Z - Unknown

Instructor rating
Y - Yes
X - No
Z - Unknown

Instrument rating
A - Airplane - Yes
B - Airplane - No
C - Helicopter - Yes
D - Helicopter - No
E - Airplane/helicopter - Yes
F - Airplane/helicopter - No
Z - Unknown

Last check—instrument rating (weeks)
Enter direct number of weeks since the last check flight followed by "S" for simulation or "F" for flight check.
z - Unknown

Last check—aircraft type
Enter direct number of weeks since the last check for the aircraft type in the same capacity as that held during the occurrence.
z - unknown

Total flight experience
Enter direct time in hours
z - unknown

Flight experience in type
Enter direct time in hours
z - unknown

Number of landings on type—last 90 days
Enter direct number of landings
z - unknown

Total time instrument flight actual
Enter direct time in hours
z - unknown

Total time instrument flight simulated
Enter direct time in hours
z - unknown

Total time instrument flight actual—last 90 days
Enter direct time in hours
z - unknown

Total time night flight
Enter direct time in hours
z - unknown

Flight time last 24 hr
Enter direct time in hours
z - unknown

Flight time last 30 days
Enter direct time in hours
z - unknown

Flight time last 90 days
Enter direct time in hours
z - unknown

Duty period prior to occurrence
(Includes duty time before takeoff plus duration of flight before occurrence)
Enter direct time in hours
z - unknown

Rest period before duty
Enter direct time in hours before subject flight
z - unknown

Medical requirements
1 - Valid medical requirement with no waivers or limitations
2 - Valid medical requirement with waivers or limitations
3 - Nonvalid medical requirement
z - unknown

Other flightcrew
Crew identifier
A - Flight engineer/systems operator
B - Flight navigator
C - Flight radio operator
S - Student pilot/pilot under instruction
D - Supervisory pilot
E - Supervisory flight engineer

F - Supervisory flight navigator
G - Supervisory flight radio operator
H - Not applicable
(See the following data fields and codes for any three of the other flightcrew as listed above)
Age
Enter direct in years
z - unknown
Validity of license
A - Valid
B - Not valid
z - Unknown
Ratings
Y - Yes
X - No
Z - Unknown

Total flight experience
Enter direct in hours

Flight experience on type
Enter direct in hours

Medical requirements
1 - Valid medical requirement with no waivers or limitations
2 - Valid medical requirement with waiver or limitations
3 - Nonvalid medical requirement
z - Unknown

Air traffic controller
(Associated with the flight at the time of the occurrence)

Age
Enter direct in years
z - unknown

License or qualifications
A - Licensed
B - State qualified
C - Neither licensed or qualified
D - No license required by state
Z - Unknown

Rating
A - Aerodrome control—without radar rating
B - Aerodrome control—with radar rating
C - Approach control—without radar rating
D - Approach control—with radar rating
E - Area control—without radar rating
F - Area control—with radar rating
G - Radar—PAR
H - Radar—SRE (surveillance)
I - No rating required by state
Z - Unknown

Experience
(In position occupied at the time of occurrence)
A - 0-1 month
B - 1-3 months
C - 3-6 months
D - 6-12 months
E - 12-24 months
F - 24-36 months
G - Over 36 months
Z - Unknown

Duty time
(Immediately prior to occurrence)
Enter direct in hours to nearest hour
Z - Unknown

Rest time before duty
Enter direct in hours to nearest hour up to 99 hr
P - Over 99 hr (99 plus)
Z - Unknown

Communications

Two-way communication
A - Established and satisfactory
B - Established but not satisfactory
C - Radio communication failure recognized by SSR Code 7600
X - Not established
Z - Unknown

Ground station
(Record last unit in communication with the aircraft)
A - Aerodrome control tower
B - Approach and departure control office
C - Area control center
D - Flight information center
E - Flight information service
F - Operator ground station
("Company frequency" or equivalent)
G - Flying Club
Y - Other
Z - Unknown

Record of R/T communication
(Select up to two items)
A - Available and functioning
B - Available and not functioning
C - Available and partially functioning
D - Transcripts made
E - Transcripts partially made
F - Transcripts not made
G - Not available
H - Not existing
Z - Unknown

Record of ATS intercommunication available
A - Available
B - Partially available
C - Not available
Z - Unknown

Medical and pathological information
General information
Autopsy performed
A - All occupants
K - Some of the occupants
B - Flightcrew only
C - Passengers only
D - None performed
Z - Unknown

Pilot In Command/Copilot/Flight Engineer/Systems Operator

Medical Information Available	Pilot In Command	Copilot	Flt Engr/ Sys Opr

Y - Yes
X - No
Z - Unknown

Incapacitation in flight
Y - Yes
X - No
Z - Unknown

Psychological investigation performed
Y - Yes
X - No
Z - unknown

Exposure to chemicals
(Toxic effect)
A - Not affected
B - Affected in flight
C - Affected on ground prior to flight
D - Not exposed
Z - Unknown

Result of toxicology investigation
(Select up to four items)
A - 10% or less
B - Over 10% Carbon Monoxide
J - No test made
E - Drug test positive
F - Drug test negative
L - No drug test made
G - Alcohol test positive
H - Alcohol test negative
M - No alcohol test made
C - Lactic acid 200% or less
D - Lactic acid over 200%
K - No lactic acid test made
N - Toxicological test results considered unreliable
I - Toxicological samples inadequate for testing
Z - Unknown

Alcohol content
(Enter blood or urine code)
A - 1 - 50 mg per 100 ml
B - 51- 120 mg per 100 ml
C - 121- 250 mg per 100 ml Blood
D - 251- 300 mg per 100 ml
E - Over 300 mg per 100 ml

H - 1 - 70 Mg per 100 ml
I - 71 - 160 mg per 100 ml Urine
J - 161- 350 mg per 100 ml
K - Over 350 mg per 100 ml

Air traffic controller
Medical information available
Y - Yes
X - No
Z - Unknown

Personnel
Pilot in command
Copilot
Dual student
Supervisory pilot

Pilot—Operational Decisions

Attempted operation with known deficiencies in equipment
Refers to instances where deficiencies in equipment are known by the pilot prior to the flight.

Attempted operation beyond experience/ability level
Refers to cases in which the pilot is not qualified in the type of aircraft or operation involved or attempted flight under conditions beyond his experience and ability.

Encountered unforeseen circumstances beyond his capability
Refers to instances in which the pilot is faced with several unforeseen or unexpected conditions or circumstances that exceed his capability.

Continued flight into known area of severe turbulence
Refers to those instances in which the pilot had prior knowledge of the possibility of severe turbulence or where the pilot deliberately continued into increasingly turbulent conditions.

Delayed action in aborting takeoff
Refers to slow reaction or faulty judgment by the pilot in not aborting in sufficient time when the circumstances indicated the advisability of such action.

Delayed in initiating missed approach or overshoot
Refers to slow reaction or faulty judgment by the pilot in delaying the initiation of a go-around, under circumstances that indicated the advisability of such action.

Retracted gear prematurely
Used in those instances during takeoff where the aircraft weight is still on the gear or the circumstances are such that the aircraft settles back to the surface during or after retraction.

Improper inflight decisions or planning
The failure to use good judgment or follow good operating procedures while in flight. Examples are failure to refuel enroute when reasonable prudence would require it, (or failure to resolve problems arising in flight), miscalculated fuel consumption, and poorly planned approach.

Exercised poor judgment
Refers to recklessness, irresponsibility, deliberate, or unnecessarily hazardous operations. This code is intended to be used primarily in those cases for which there is no other descriptive factor (in the pilot area) to reflect the act of recklessness.

Selected unsuitable area for takeoff, landing, or taxiing
Includes all cases where a pilot selected an unsuitable area for taxi, takeoff, or landing. Excludes cases where the pilot exercises normal and reasonable precautions, but encounters hidden hazards or conditions not easily determined. Excludes forced landing unless pilot definitely had the choice of a more suitable area.

Selected wrong runway relative to existing wind
Factor of pilot judgment

Failed to abort takeoff
Factor of pilot judgment

Failed to initiate go-around/missed approach/overshoot
Factor of pilot judgment

Initiated flight in adverse weather conditions

Pilot—Procedures, Regulations, and Instructions

Attempted operation beyond experience or ability level
Refers to cases in which the pilot is not qualified in the type of aircraft or operation involved or attempted flight under conditions beyond his experience ability.

Continued VFR flight into adverse weather conditions
Includes those instances where VFR flight was attempted or continued in adverse weather conditions. If loss of control results, code 66, "spatial disorientation," will also be coded as a factor.

Diverted attention from operation of aircraft
Refers to the failure of the pilot to give the degree of attention required, under the circumstances, to the operation of the aircraft.

Exceeded designed stress limits of aircraft
Refers to instances of overstressing of the airframe, whether of a willful nature or due to lack of ability and experience.

Failed to follow approved procedures, directives, instructions, etc.
Disregard of standard procedures, written or verbal instructions, directives, operations manuals, etc., when such are known by, or available to, the pilot.

Improper IFR operation
Includes improper operation of the aircraft and its equipment and/or failure to use or incorrectly use standard procedures and techniques while on an instrument flight; includes VFR landing after "last light."

Inadequate preflight preparation and/or planning
Refers to ground preparation for flight. The preflight check of the aircraft and its equipment, the planning of the flight, weather briefing, fuel reserve, etc., are examples of action which could be improperly performed or omitted.

Inadequate supervision of flight
Refers to cases where a pilot in command fails to exercise the degree of supervision required by the circumstances. Includes failure of an instructor to take over controls in time to prevent an accident.

Mismanagement of fuel
Refers to the improper operation of, or lack of attention to, fuel supply. Examples are the failure to turn the proper tank on or to switch to the proper tank; includes miscalculation of fuel consumption.

Operated carelessly (unintentional or forgot)
Refers to acts of neglect, forgetfulness, or carelessness, not of a deliberate or intentional nature.

Improper starting procedures
Used where engine starting procedures either in flight or on the ground, results in failure to start or an unwanted condition, e.g., an engine overspeed or fire.

Started engine without proper assistance and/or equipment
Refers to cases where an engine is started by pulling the propeller through without a qualified person seated in the cockpit and/or without proper equipment such as wheel chocks.

Taxied or parked without proper assistance
Used in cases where normal prudence would dictate the use of outside assistance such as wing walkers, signalers, etc., if available, e.g., taxiing in confined or dark unlighted areas or when wind or other weather conditions are such that the use of outside assistance is indicated.

Failed to check position and locking of the landing gear
Failure of pilot to check gear position and locking after actuating gear controls.

Failed to relinquish control
Generally refers to failure of student, copilot, etc., to relinquish control to the pilot in command in time for effective corrective action to be taken.

Control interference (includes all controls)
Interference with the controls by a pilot other than the pilot actually flying the aircraft. (Flight control interference by a passenger is coded 68 K4 "passenger," code 88 77 "interference with flight controls." Interference with flight controls by inanimate objects is coded 88 77 with object identified in remarks.)

Left aircraft unattended, engine running
Factor of pilot judgment.

Pilot—Aircraft Handling

Failed to obtain or maintain flying speed
Failure of the pilot to obtain and/or maintain sufficient airspeed for the conditions involved.

Maintained excessive airspeed
Refers to cases where a pilot maintains excessive airspeed for the operation and conditions involved.

Failed to maintain adequate rotor rpm
Loss of rotor rpm due to pilot action or inaction.

Improper operation of powerplant controls
Improper operation of the powerplant from a mechanical standpoint, through improper use of throttles, supercharger cowl flaps, carburetor heat, mixture controls, propeller controls, etc., under the conditions and circumstances involved.

Improper operation of brakes and/or flight controls on ground
Refers to cases involving poor or inadequate pilot "technique" in the operation of the brakes and/or flight controls on the ground. Includes landing roll or takeoff run and taxi.

Improper operation of primary flight controls
Refers to pilot "technique" in the operation of flight controls in the air; includes trim control and excludes flaps and spoilers.

Premature liftoff
Allowing an aircraft to become airborne without sufficient speed for proper climb or control.

Approached high and fast
Refers to cases where a pilot maintains an excessive angle of approach, height, or airspeed during a landing approach.

Improper landing flare
Leveling off too high on a landing or failure to break glide properly and flying into the ground.

Improper compensation for wind conditions
Failure to make proper drift corrections or allowances for the wind conditions prevailing when taxiing, taking off, or landing.

Improper recovery from bounced landing
Factor of pilot technique.

Failed to maintain directional control
A general code used when the cause of the loss of control is not clear. Generally used in conjunction with loss of control during takeoff or landing.

Misused or failed to use flaps (or other lift devices)
Factor of pilot judgment, training, lack of familiarly with the aircraft, or carelessness.

Misused or failed to use lift dump devices (spoilers, etc.)

Pilot—Medical

Incapacitation

Physical impairment

Spatial disorientation (vertigo)

Psychological condition
Used when the pilot's actions or words indicate a mentally disturbed state, e.g., tells the tower he is going to commit suicide by crashing the aircraft.

Pilot—Miscellaneous

Became lost or disoriented
Refers to improper or faulty navigation resulting in becoming lost under VFR conditions.

Failed to see or avoid other aircraft
Used where there is complete failure to see and avoid another aircraft and also where the pilot sees the other aircraft too late to avoid it.

Failed to see or avoid objects or obstructions
Used where there is complete failure to see and avoid objects or obstructions other than aircraft and also where the pilot sees the object or obstructions too late to avoid it.

Spontaneous—improper action
A reflex type action that may or may not have a logical explanation.

Lack of familiarity with aircraft
Refers to lack of experience with the aircraft involved for the type of operation attempted. It is not used interchangeably with "attempted operation beyond experience or ability level" as it is more specific and could apply to a pilot of broad general experience.

Inadequate training of student (instructor in airplane)
Factor of training inadequacy.

Misunderstanding of orders or instructions (including ATC clearances)
Refers to verbal orders or instructions, e.g., clearances, instructor's orders or instructions to student, etc.

Navigation Error
Refers to displacement from intended track in enroute flight.

Encountered unforeseen circumstances beyond his capability
Refers to instances in which the pilot is faced with several unforeseen or unexpected conditions or circumstances that exceed his capability.

Other

Other Personnel

Other pilot same aircraft
Failure to comply with company procedures

Improper use/operation of equipment

Gave incorrect information to other crewmembers

Failure to follow instructions

Other

Flight Engineer/Systems Operator
Improper use of equipment/operation of equipment

Inadequate preflight preparation

Failure to follow instructions

Other

Navigator

Radio operator

Other flight personnel
Flight attendant

Flight instructor (on ground)
Inadequate supervision of flight

Inadequate training of student

Other

Flight operations officer (flight dispatcher)
Dispatched aircraft improperly equipped for flight

Failed to comply with proper dispatching procedures

Disregard of adverse weather conditions

Cleared flight with inadequate facilities at destination

Dispatched flight overweight or with improper center of gravity

Failed to keep flight properly advised (flight following)

Other

Maintenance, Servicing, and Inspection Personnel
Improper maintenance (maintenance personnel)
Improper maintenance (owner personnel)
Improperly serviced aircraft (ground crew)
Improperly serviced aircraft (owner pilot)
Inadequate inspection of aircraft (maintenance personnel)
Inadequate inspection of aircraft (owner-pilot personnel)
Inadequate maintenance and inspection
Other (including failure to observe license limitations, etc.)
Unknown

Operational Supervisory Personnel
(Company, owner, operator)
Inadequate flight training—procedures
Inadequate ground training—procedures
Inadequate supervision of flightcrew
Inadequate supervision/training of ramp crews (signalmen, etc.)
Failure to provide adequate directives, manuals, and equipment
Deficiency, company maintained equipment, services, regulation manuals, etc.
Other

Meteorological Personnel
Incorrect weather forecast
Inadequate or incorrect weather observation or meteorological watch
Incomplete weather report
Inadequately maintained facilities
Training deficiency
Inadequate or incorrect weather briefing
Inadequate or incorrect coordination
Other

Air Traffic Services Personnel
Failure or delay in providing alerting service
Failure to advise of hazardous weather condition
Failure to advise of hazardous airport condition
Failure to advise of other traffic
Cleared aircraft to wrong runway for existing conditions

Issued improper or conflicting instructions
Inadequate spacing of aircraft
Failure to properly identify aircraft on radar
Other

Airport Supervisory Personnel
(Airport management)
Improper maintenance—airport facilities (includes "marking"—amplify in remarks)
Failure to notify of hazardous condition and/or failure to mark obstruction
Improper or inadequate snow removal
Improper operation of facilities
Improper inspection and/or reporting of facilities
Other

Air Traffic Services Maintenance Personnel
Inadequately maintained airways facilities
Inadequately maintained approach facilities
Failure to notify hazardous condition
Improper removal of facilities from service
Other

Production—Design
Substandard quality control
Incorrect factory installation
Poor or inadequate design
Other

Miscellaneous Personnel
Pilot of other aircraft
Ground signalman
Spectator
Ground crewman
Passenger
Driver of vehicle
Operational Control/SAR
Flight Service
Airport Safety Service
Other (including military and fuel servicing personnel)

Additional Facts, Conditions, and Circumstances
ACTION—lack of (see also psychological condition)
ADI (Antidetonant injection) fluid improper
ADJUSTMENT /alignment improper (see also CLEARANCE)

C-2

AIRPORT—landed or approached wrong airport or runway
ALCOHOLIC impairment of efficiency and judgment
ALTIMETER setting incorrect (cockpit)
APPROACH poorly planned
BLIND CANYON—flew into
BOGGED—aircraft became bogged (mired)
BRITTLE fracture (due to improper forging, heat treatment, etc.)
CARBON MONOXIDE poisoning
CARBURETOR heat equipment—improper operation or failed to use (see also ICE carburetor or ICE induction)
CARGO shifted (see also SECURED—improperly)
CENTER OF GRAVITY out of limits (see LOADED improperly)
CHECKLIST—failed to use
CONSTRUCTION AREA—landed in
CORRECTING LENSES required but not used
COWL FLAPS improperly positioned
CREW COORDINATION inadequate
CROSSED (e.g., threaded parts, control cables, and electrical connections)
DANGEROUS CARGO (radioactive/hazardous materials, acids, etc.)
DISREGARD of good operating practice
DOWNWIND landing or takeoff
EMERGENCY PROCEDURES improperly used/not used
ENGINE—shut down wrong
ENGINE—leaded up (leaded plugs)
EVASIVE maneuver
FATIGUE, pilot
FLAP/SLAT, etc.—premature retraction of
FLUID level low (see also LEAK)
FUEL consumption miscalculated
FUEL contamination (exclusive of water, see WATER in fuel)
FUEL dumped (intentional)
FUEL exhaustion (ran out of fuel) (see also FUEL starvation)
FUEL grade improper
FUEL selector—positioned between tanks
FUEL spill
FUEL starvation (see also FUEL exhaustion)
FUEL supply—inattentive to
GLASSES see CORRECTING LENSES
GROUND/WATER loop swerve intentional
GUST LOCKS (controls) engaged
HAZARDOUS MATERIALS see DANGEROUS CARGO
HEART ATTACK—pilot suffered
HOT START

HYPERVENTILATION
HYPOXIA/ANOXIA
IMBALANCE lateral
IMPROPER loading/securing/carriage of passengers/cargo
(see also CARGO shifter and LOADED improperly)
INATTENTION (to be used for "Other Personnel")
INSTALLED improperly (i.e., in a manner not in accordance
with specific or accepted practice)
(see also ADJUSTMENT and/or ALIGNMENT)
INSTRUCTIONS misinterpreted (other than copilot)
INSTRUMENTS—misread or failed to read
LANDING on wrong runway or airport
LEADED plugs (ENGINE leaded up)
LIGHTS—failed to use landing lights
LOAD jettisoned
LOAD not jettisoned
LOADED improperly (in respect of aircraft weight or center of gravity)
LOOSE part of fitting (see also UNDERTORQUED)
LOW flying—unwarranted
LUBRICATION—lack of (not system but specific part - see also OIL)
MODIFICATION unapproved (see also PART - wrong)
OIL contamination
OIL exhaustion—engine lubrication system (see also OIL starvation, LEAK)
OIL exhaustion—propeller system, (see also LEAK)
OIL grade—improper—lubrication system
OIL grade—improper—propeller system
OIL starvation (see also OIL exhaustion, LEAK, lubrication lack of)
OPTICAL ILLUSION—pilot experienced an
OVERLOADED—aircraft weight (see LOADED improperly)
OXYGEN SYSTEM—improper use of or failed to use
PART bogus (not genuine; of unauthorized manufacture
PART wrong
PILOT/CREW made equipment inoperative (e.g., switched off equipment, system, etc.)
PROCEDURES see EMERGENCY
RAN OFF RUNWAY END
RUNWAY—failed to use all available
RUNWAY/intended landing area—not aligned with
RUNWAY—landed on foamed runway
SEAT belt not fastened
SEAT belt sign off
SEAT belt sign on and not obeyed
SECURED improperly (see also CARGO shifted)
SLING/LOAD snagged/caught (rotorcraft)

SPECTACLES see CORRECTING LENSES
START hot
THRUST reversal—asymmetrical or incomplete
TOUCH-AND-GO LANDING
TRIM setting incorrect
UNQUALIFIED person operated aircraft
WEIGHT—aircraft (see LOADED improperly)
WHEELS UP - intentional
WORK LOAD EXCESSIVE
WRONG airport/runway—landed on (see AIRPORT)
PERSONNEL—other

Rasmussen, J., 1982

Multifacet Taxonomy for Description and Analysis of Events Involving Human Malfunction

1. Causes of human malfunction
   a. External events (distraction, etc.)
   b. Excessive task demand (force, time, knowledge, etc.)
   c. Operator incapacitated (sickness, etc.)
   d. Intrinsic human variability

2. Performance shaping factors
   a. Subjective goals and intentions
   b. Mental load and resources
   c. Effective factors

3. Situation factors
   a. Task characteristics
   b. Physical environment
   c. Work time characteristics

4. Mechanisms of human malfunction
   a. Discrimination
      (1) Stereotype fixation
      (2) Familiar shortcut
      (3) Stereotype takeover
      (4) Familiar pattern not recognized
   b. Input information processing
      (1) Information not received
      (2) Misinterpretation
      (3) Assumption
   c. Recall

(1) Forget isolated act
(2) Mistake alternative
(3) Other slip of memory

d. Inference
(1) Condition or side effect
(2) Not considered

e. Physical coordination
(1) Motor variability
(2) Spatial misorientation

5. Internal human malfunction
a. Detection
b. Identification
c. Decision
(1) Select goal
(2) Select target
(3) Select task

d. Action
(1) Procedure
(2) Execution
(3) Communication

6. Personnel task
a. Equipment design
b. Procedure design
c. Fabrication
d. Installation
e. Inspection
f. Operation
g. Test and calibration
h. Maintenance and repair
i. Logistics
j. Administration
k. Management

7. External mode of malfunction
a. Specified task not performed
(1) Omission of set
(2) Inaccurate performance
(3) Wrong timing

b. Commission of erroneous act
c. Commission of extraneous act
d. Sneak-path, accidental timing of several events, or faults

APPENDIX 2

HUMAN ERROR REFERENCE LIST

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APPENDIX 3

GLOSSARY OF HUMAN ERROR TERMS
(terms not included in the SAE G-10 Human Factors Glossary)

Acceleration Cardiovascular Effects/ACE - (AFP) Reduction in performance capability due to grayout (loss of peripheral vision due to positive "G"), blackout (loss of all vision due to positive "G"), or loss of consciousness due to positive "G." Analogous negative "G" effects also exist.

ACE-Lateral - (AFP) Gy forces. This is associated with canard flight control surfaces, which has caused up to 2.5 Gy (without cardiovascular difficulty).

ACE-Negative - (AFP) When red out occurs, it is associated with substantial negative (2.5 to 3) "G" for 3 to 5 sec.

ACE-Rapid Onset - (AFP) Usually associated with loss of consciousness as a result of transition from normal to high (> 7) "G" in a period less than 3 sec and a warning "grayout" is thus not seen.

Acceleration Orientation Effects - (AFP) Influence on performance capability due to the effects of acceleration on the proprioceptive tactile or vestibular apparatus. See Ambient Orientation.

(BASI) An impaired condition caused by "G" forces on the body. This includes loss of consciousness, reduced visual perception, and all other physical and physiological reactions to "G" loads.

Acceleration Tolerance: (AFP) The ability of an individual to preserve performance capability in the face of the various effects of acceleration. See Physical Condition.

Accident: (BASI) ANR defines an accident as an occurrence associated with the operation of the aircraft that takes place between the time any person boards the aircraft with the intention of flight until such time as all persons have disembarked in which (1) any person suffers death or serious injury as a result of being in or on the aircraft or by direct contact with the aircraft or anything attached to the aircraft, except when the injuries are from natural causes, are self-inflicted, or inflicted by other persons or when the injuries are to stowaways hiding outside the area normally available to the passengers and crew; (2) the aircraft incurs damage or structural failure that adversely affects the structure strength, performance, or flight characteristic of the aircraft and would normally require major repair or replacement of the affected component; or (3) the aircraft is missing or inaccessible.

(Annex 13) - An occurrence associated with the operation of an aircraft that takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, in which (1) a person is fatally or seriously injured as a result of being in the aircraft or direct contact with any part of the aircraft, including parts that have become detached from the aircraft or direct exposure to jet blast, except when the injuries are from natural causes, self-inflicted, or inflicted by

other persons or when the injuries are to stowaways hiding outside the areas normally available to the passengers and crew; (2) the aircraft sustains damage or structural failure that adversely affects the structure strength, performance, or flight characteristics of the aircraft and would normally require major repair or replacement of the affected component, except for engine failure or damage, when the damage is limited to the engine, its cowlings, or accessories or for damage limited to propellers, wingtips, antennas, tires, brakes fairings, small dents, or puncture holes in the aircraft skin; or (3) the aircraft is missing or is completely inaccessible.

Note 1: For statistical uniformity only, an injury resulting in death within 30 days of the date of the accident, is classified as a fatal injury by ICAO.

Note 2: An aircraft is considered to be missing when the official search has been terminated and the wreckage has not been located.

(Barnhart, et al., 1975) - An occurrence associated with the operation of an aircraft that takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, in which any person suffers death or serious injury as a result of being in or on the aircraft or by direct contact with the aircraft or anything attached thereto or the aircraft receives substantial damage.

Accident, Antecedent Events: (BASI) Those events or conditions that occurred prior to the demonstration of intent for flight but which relate to the conditions making the accident more likely (e.g., fatigue and get-home-itis).

Accident, Maneuver: (BASI) A subelement of the accident phase of flight described by the sequence of tasks required to perform the event (e.g., turn out of traffic, go-around, etc.).

Accident, Point of: (BASI) That point in the accident sequence of events at which no preventative or evasive action by the pilot would have avoided the accident.

Accident, Predisposing Events: (BASI) Those events or conditions more general in nature or more long-standing than accident antecedent events, but that are predisposing to accident occurrence (e.g., risk-taking tendencies and lax supervision).

Accident, Sequence: (BASI) A series of events, one or more of which must involve human action, that eventually results in (i.e., terminates in) an accident.

Accident, Task: (BASI) A subelement of the accident maneuver that describes each specific action required of the pilot to accomplish that maneuver (e.g., controls and display, target tracking, and aircraft positioning).

Accident Rate: (BASI) For statistical purposes, the number of air accidents may be quoted as a "rate". This rate is calculated per 100 000 flying hours.

Accident Zone: (Gerbert and Kemmler, 1985) Performance demands exceed the actual performance ability thus provoking errors leading to accidents. Prevailing 'internal' factors in the origination of failures and critical situations are physical factors, psychological factors, and pilot's proficiency factors. Prevailing 'external' factors in the origination of failures and critical situations are environmental factors, mission requirement factors, organizational and supervisory factors, technical and design factors.

Accredited Representative: (Annex 13) A person designated by a state, on the basis of his qualifications, for the purpose of participating in an investigation by another state.

Acrophase: (Klein and Wegmann, 1980) Phase angle of the maximum in a sinusoidal function or in a function used to approximate a rhythm; given in units of time, angular degrees, or radians.

Acute or Transient Fatigue: See Fatigue, Acute/Transient.

Acute or Transient Performance Decrement: (AFP) The type of exhaustion associated with physical or mental activity between two regular sleep periods. Acute or transient performance decrement is eliminated after a regular sleep period.

Adjustment Error: See Error, Technical.

Adviser: (Annex 13) A person appointed by a state, on the basis of his qualifications, for the purpose of assisting its accredited representative at an investigation.

Aerobatic Demonstration: (BASI) Aerobatics intended to demonstrate pilot skill and/or to demonstrate aircraft capabilities.

(AFP) Aerobatics intended to demonstrate pilot skill and aircraft capabilities.

Aerospace Medicine: (AFP) A medical specialty dealing with prevention, especially dealing with the environments related to flight and individual capabilities in meeting those demands. Flight surgeons receive at least a basic course reviewing these concerns in addition to whatever physician training they hold.

Affective States: (BASI) Subjective feelings of different types of pleasantness or unpleasantness that a person has about aspects of his environment, other people, or himself. Affective states are subdivided into moods and emotions depending on their duration and intensity.

> **Emotions** - (BASI) A complex temporary state marked by strong feelings, bodily changes, and mental excitement or perturbation. Emotions are relatively brief in duration, but strong in intensity.

(AFP) An excited affective state that tends to be disruptive of mental, physiological, or behavioral process. Emotions are relatively brief in duration but strong in intensity (may be influenced by fatigue or various stressors).

Mood - (BASI) An affective state or attitude of relatively low intensity, but long in duration.

(AFP) An affective state of relatively low intensity, but long in duration. A mood can facilitate a perceptual or response set.

Aircraft: (Annex 13) Any machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the earth's surface.

Alcohol: (BASI) "Misuse" is deemed to have occurred when a member's use of alcohol—

1. Interferes with his performance of duty or regular attendance at the place of duty.
2. Creates an administrative burden by causing domestic or other problems.
3. Interferes with his satisfactory social or economic functioning.
4. Interferes with his health.

Ambient Orientation: (AFP) A means of maintaining gross orientation without "thinking" about it. It is the result of the preconscious level of awareness keeping track of various sensory inputs (including peripheral visual, tactile, kinesthetic, vestibular, and auditory) to keep us oriented with respect to the various inputs. Discontinuity between such inputs is thought to predispose to motion sickness. In vision this involves peripheral vision.

Amplitude: (Klein and Wegmann, 1980) Difference between maximum and mean value, between value, or between minimum and mean value.

Anomaly: (Barnhart, et al., 1975) A deviation from the common rule; an irregularity. As used here, an anomaly is a departure from normal or expected performance in the course of a mission. The departure from normal operation may be that of the airplane, including its components, its crew, or others concerned with the direction and control of aircraft. Synonym: Operational anomaly. A behavioral anomaly is a departure from normal or expected performance of some person—an error. Carl Lager's term "dysfunction"—an unwanted result of operation, an unwanted system state, or unwanted component response—is analogous.

Antecedent Events/Mishap: See Mishap, Antecedent Events.

Anthropometrics: (BASI) Measurement of the physical height, weight, build, and dimensions of a person.

(AFP) Measurement of the physical height, weight, build, and dimensions of a person. (Used in solving biomechanical issues in equipment design.)

Approach Phase: (AFP) Final approach fix to missed approach point for an instrument approach; from reaching traffic pattern altitude until crossing the runway threshold for a visual approach. A go-around is considered part of the approach phase if it occurs before the missed approach point for an instrument approach or before crossing the runway threshold for a visual approach.

Attention: (BASI) Investment of some level of awareness towards a certain task.

(AFP) The use of some level of conscious mental or cognitive resources in processing information. See Vigilance.

Attention, Anomalies of: (AFP) Misallocation or untimely interruption of attention to a task (all may be influenced by fatigue or various stressors).

Boredom - (BASI) A state of reduced conscious attention due to a perceived unchallenging environment. A dull, undemanding task may lead to low level of awareness and compromise a response in an emergency.

Channelized Attention - (BASI) When a person's full attention is focused on one stimulus to the exclusion of all others. This becomes a problem when the person fails to perform tasks or process information of a higher or more immediate priority and thus fails to notice or has no time to respond to cues requiring immediate attention.

Cognitive Task Saturation - (BASI) The situation in which the quantity or quality of necessary information to process or the number or complexity of the decisions to be made, exceeds a person's capacity. The span of attention is insufficient for the task. See Channelized Attention.

Complacency - (BASI) A state of reduced conscious attention or awareness due to a sense of security, self-confidence, or a perceived absence of threat from the environment.

Distraction - (BASI) When a person's focus of attention on tasks is interrupted by the introduction of another stimulus unrelated to the task he is currently performing.

Fascination - (BASI) An anomaly of attention in which a person monitors the relevant environmental cues around them, but fails to respond to them because of a sense of unreality or detachment from events, as if he were viewing them from the outside. Fascination is usually associated with a high-stress situation.

Habit-Pattern Interference - (BASI) Reverting to previously learned response modes that are inappropriate to the task at hand. Habit pattern interference usually occurs at the preconscious level of awareness. See Learning - Learning Transfer.

Habit Pattern Substitution: (BASI) (AFP) Reverting to previously learned and (objectively, AFP) inappropriate response modes when the appropriate response is unavailable due to a lack

of procedural knowledge. Habit pattern substitution usually occurs at the conscious level of awareness.

Inattention - (BASI) An inappropriately low level of attentiveness to a task and/or failure to attend to all of the relevant environment cues.

Focus of Attention - (BASI) That part of the span of attention directed toward conscious information processing.

Span of Attention - (BASI) The total individual capacity to invest conscious attention.

(AFP) The total individual cognitive or attentional resources, both in quantity and duration, to process information at the conscious level.

Attitude, Aircraft: (AFP) The orientation of the three major axes of an aircraft (longitudinal, lateral, and vertical) with respect to a fixed reference such as the horizon, the relative wind, or direction of flight.

Attitude, Personal: (AFP) An enduring, learned predisposition to behave in a consistent way toward a given circumstance; a persistent mental state of readiness to react to a certain circumstance, not as they are but as they are conceived to be.

Awareness, Level of: (AFP) The theoretical level of cognitive or mental function resulting in our behavior.

Background: (Barnhart, et al., 1975) This term includes all relevant activities to the conduct of a mission that take place prior to the beginning of a flight.

Base Leg: See Traffic Pattern.

Behavioral Profile: (Stoklosa, 1983) Illustrates ways in which an operator interacts with the environment and the behavioral repertoire that he/she brings to an operating situation. Factual information is gathered on 24- to 72-hr history, operator behavior, life habit patterns, and life events.

Boredom: See Attention, Anomalies of.

Briefing Inadequacy: (AFP) When a mission element that should have been briefed was not or was inadvertently briefed, briefing is considered a factor. Normal tasks, such as lowering the gear for landing, are not considered mandatory briefing items, and briefing is not considered inadequate when such tasks are not covered.

Busting: (AFP) Failure to perform to a standard (as in "busting" a maneuver sortie).

Carelessness: (BASI) Did not exercise due care. Display of indifference, laxity, or disregard of established procedures.

Cause: (Annex 13) Action(s), omission(s), condition(s), or a combination thereof, which led to the accident or incident.

Cause Factor: (BASI) A cause factor is defined as being any event, condition, or circumstances, the presence or absence of each, within reason, increased the likelihood of an aircraft occurrence.

Channelized Attention: See Attention, Anomalies of.

Chokes: See Decompression Sickness.

Circadian: (Klein and Wegmann, 1980) With a period of approximately 24 hr (strictly 20 to 28 hr); CIRCA (about, approximately) and DIES (day, 24 hr).

Circadian Rhythm: (AFP) The tendency for some biological process to recur at regular intervals within sequential 24-hr periods.

Circadian Rhythm Upset: (BASI) Performance decrement due to an upset in the biological process, (e.g., body temperature and hormonal activity) as a result of crossing several time zones quickly or different work shifts with inadequate transition periods between them.

Clearance: (AFP) Authorization by a traffic control facility for an aircraft to proceed within controlled airspace.

Climbout Phase: (AFP) From the time of configuring for climbout to reaching cruise altitude.

Cockpit Resource Management: (BASI) Cockpit resource management refers to the effective utilization of flightcrew members to enhance crew interaction, communication, and decision making in multicrew aircraft operation. (The term can be extended to refer also to the effective utilization of all available resources in decision making in single pilot operations.)

(AFP) The aircrew's prioritized, coordinated, and timely use of available resources, to include use of automation, delegation of tasks to other crewmembers, effective communication, and interface with control agencies. (Indicates enforcement of crew coordination.)

Cognitive (Mental) Flexibility: (AFP) An individual's ability to shift from one mental task to another or to effectively timeshare between several tasks while maintaining situational awareness.

Cognitive Task Saturation: See Attention, Anomalies of.

Command and Control: (AFP) The orderly distribution of authority and responsibility designed to systematically accomplish a mission and the continuous-feedback-loop communications network connecting all levels of command so that decisions can be made, efforts coordinated, and discipline maintained. Command and control are considered factors when supervision is inadequate or when procedures over which the MAJCOM has control are inadequate, nonexistent, or characterized by inadequate supervision at unit or wing level or inadequate mission planning scheduling. Failure to monitor the conduct of operations or failure to provide close inflight supervision where training and proficiency are suspect are also indicators of command and control deficiencies.

Command/Control: (BASI) The orderly distribution of authority and responsibility designed to systematically accomplish a flight and the continuous-feedback-loop communication network connecting all levels of command so that decisions can be made, effort coordinated, and discipline maintained.

Communication: (BASI) To include interpersonnel communication at all levels and also communication discipline (i.e., aircrew; ATC).

Communication Problems: (AFP) Information transfer ineffectiveness.

Equipment Failure.
Message Content - Garbled, inaccurate, or ambiguous.
Message Generation - Message not originated.
Message Reception - Receiving party did not receive or understand.
Message Timing - Message correct, but not timely.

Confidence: (BASI) A personality characteristic that allows one to act with some degree of self-assurance. Overconfidence and lack of confidence may degrade one's ability to make rational judgments or decisions in the performance of his tasks.

Overconfidence - (AFP) An attitude in which a person assumes that he or she can perform a task, even though this may not be true, because he or she has not successfully performed it in the past, has performed it in the past but under different circumstances, or because it is unrealistic to attempt it at all.

Underconfidence - (AFP) An attitude in which a person assumes that he or she cannot perform a task, even though he or she has the demonstrated capabilities necessary.

Confusion: (AFP) Loss of situational awareness that is recognized by the individual concerned. A state characterized by bewilderment, emotional disturbance, lack of clear thinking, and (sometimes) perceptual disorientation.

Conscious Level: See Awareness, Level of.

Contingency: (AFP) One or more contributing factors that influence a situation, but may not be inherently hazardous (e.g., unforecast bad weather, ATC delays, supervisor comments, and unspoken or written rules).

Contingency Discrimination: (AFP) The process of effectively rank ordering environmental considerations by importance in terms of real and near term consequences as perceived by the individual.

Copilot Syndrome: (AFP) An attitude resulting in ineffective crew coordination based on the comforting premise that one or more other crewmembers have the situation under control and are looking out for your best interest. Implicit in the term "other crewmembers" are other nonflight members, such as ATC, the command post, and RAPCON. Rank may at times play a role.

(BASI) Ineffective crew coordination based on the comforting premise that one or more other crewmembers have the situation under control and are looking out for your best interests.

Coping Style: (AFP) Individual techniques for responding to environmental challenge (may be personality dependent).

Coriolis Illusion: See Illusion, Vestibular.

Crew Coordination: (BASI) (AFP) The systematic division of subtasks between crew or flight members so as to accomplish a larger task more efficiently. Crew coordination is the most basic level of command and control.

Critical Angle of Attack: (AFP) The minimum angle of attack of a given airfoil or airfoil section at which extensive flow separation occurs, with consequent loss of lift and increase of drag; generally results in stalling of the airfoil.

Cruise Phase: (AFP) From reaching cruise altitude to arrival at the area of range activity or from leaving the range activity to beginning descent into the base of intended landing.

Cumulative or Chronic Performance Decrement: (AFP) The type of exhaustion resulting from an inadequate recovery from successive periods of acute or transient fatigue. One regular sleep period will not eliminate cumulative fatigue; however, several sleep periods and reduced interim activity will eliminate it.

Damage: (BASI) Annex 13 defines substantial damage in the same manner as ANR 270 (b) except for the following exemptions:

"Except for engine failure or damage, when the damage is limited to the engine, its cowlings, or accessories or for damage limited to propellers, wingtips, antennas, tires, brakes, fairings, small dents, or puncture holes in the aircraft skin."

Annex 13 provides the following note in respect of missing aircraft: "An aircraft is considered to be missing when the official search has been terminated and the wreckage has not been located."

Decision: (AFP) The perception of information and selection of a response designed to achieve a desired goal after having made a judgment as to significance and priority. There are four main types: (1) information processed, correct decision, (2) information processed, incorrect decision, (3) information not adequately processed, incorrect decision, and (4) information not adequately processed, correct decision.

> **Poor Decision** - (AFP) Selection of an inappropriate response assuming adequate information and time to decide. (May be a result of diminished personal capacity due to stressors or fatigue.)
>
> **Indecision** - (AFP) Wavering between two or more responses resulting in failure to select a response in a timely manner.

Decompression Sickness: (BASI) Effects produced by evolution of gas (usually nitrogen) from tissues and fluids in the body due to changes in barometric pressure, resulting in impairment or incapacitation of the aircrew.

(AFP) Effects produced by evolution of gas (usually nitrogen) from tissues and fluids in the body due to changes in barometric pressure (symptoms may also result from air embolism).

> **Chokes** - (AFP) Deep and sharp pain centrally located under the sternum most often due to nitrogen evolving from the blood and locating in the smaller blood vessels of the lungs and producing a dry, nonproductive cough.

Delayed Perception: See Perception.

Delayed Response: See Response.

Department of Defense Flight Information Publications: (AFP) Publications used for flight planning, enroute, and terminal operations. FLIPs are produced by the Defense Mapping Agency for worldwide use. In route charts and instrument approach procedure charts are incorporated in DOD FLIPs for use in the National Airspace System (NAS).

Descent Phase: (AFP) From the initial approach fix to the final approach fix for an instrument descent; from beginning descent from cruise altitude to the final approach fix for an enroute descent to an instrument approach; from beginning descent from cruise altitude until reaching traffic pattern altitude for an enroute descent to a visual approach. Holding is considered part of the descent phase of flight.

Desynchronization: (Klein and Wegmann, 1980) State in which different rhythms previously synchronized run with different periods.

Discipline (Personal): (AFP) Discipline is evident when an individual willfully adheres to known and understood directives or restrictions.

Discipline Enforcement: (AFP) Discipline enforcement is the process of supervisory support of known principles, rules, or directives.

Dissociation, Internal: (Klein and Wegmann, 1980) Transitory state in which different rhythms within one organism temporarily loose their mutual phase relationship (e.g., adjustment to a change in external Zeitgeber with a different speed).

Distraction: See Attention, Anomalies of.

Distress: (AFP) An effective state of feeling pressure or threat, usually at the limit of coping skills and associated with physiological changes and perhaps symptoms (see General Adaptation Syndrome). Behavior under a condition of distress will tend to be a behavior that was learned earlier than the appropriate one or one that was overlearned.

Double Standard: (BASI) The stated or implied condoning of violations of established rules in the interest of flight accomplishment or a perception that the rules do not apply to everyone.

(AFP) The stated or implied condoning of violations of established rules or a perception that the rules do not apply to everyone.

Drugs: (BASI) Any chemical compound taken for purposes of prevention of disease, treatment of disease, weight management, mood alteration, or birth control. The effects may be direct or residual, but either may reduce performance capability.

Emergency: (BASI) A sudden unplanned occurrence that jeopardizes the safe completion of the flight and requires specific and timely action to avoid damage or injury.

(AFP) An unplanned occurrence that jeopardizes the safe completion of a task and requires specific and timely action to avoid damage or injury.

Emotion: See Affective States.

Endogenous Rhythm: (Klein and Wegmann, 1980) Self-sustained biological rhythm maintained from within the organism independently of external periodicities.

Entrainment: (Klein and Wegmann, 1980) Steady state in which a self-sustained rhythm runs synchronously with a Zeitgeber.

Envelope (Personal): (AFP) The real range of physical and mental capacity of an individual that varies in time.

Environmental factors: (Gerbert and Kemmler, 1985) Sudden transition from VMC to IMC, restrictions in visibility due to weather phenomena, turbulence, or vibration.

Environmental Profile: (Gerbert and Kemmler, 1985) Involves intrinsic and extrinsic physical factors that could affect performance. Factual information is gathered on internal and external conditions, illumination, and noise, vibration, and motion. Requires consideration of such issues as weather conditions, temperature, carbon monoxide, artificial light sources, and speech communication interference.

Equipment Design Profile: (Stoklosa, 1983) Operator-equipment interaction dynamics includes workspace interface, display and control design, and seat and design configuration. It also includes layout, anthropometry, communications, and other user considerations.

Equipment Malfunction: (AFP) This factor is used to refer to the occasions when an aircraft failure or malfunction, rather than a mission element, caused the pilot to be distracted or otherwise fail to accomplish the task at hand.

Ergonomics: (BASI) (Human Engineering) Human factors engineering studies of machine design and workspace environment so that they match human capacities and limitations. Human engineering problems in the cockpit may in many cases, be known by the pilots but are lived with. These factors should be discussed in a human factors investigation to determine probability of disorientation, confusion of control, or misreading of instruments. Design factors to be investigated include (1) design of instruments and controls, (2) location of instruments and controls, (3) cockpit lighting, (4) cockpit visual obstruction, (5) personal equipment interference, (6) workspace compatibility with operator, (7) habit interference and using wrong control, (8) confusion of control and switches, (9) misread instruments, (10) misinterpreted instrument reading, (11) mislead by faulty instrument, and (12) visual restriction by structures.

Error: (BASI) An unintended and inappropriate physical or mental operation.

(Barnhart, et al., 1975) An act involving a departure from accuracy; a mistake.

Error, Adjustment: See Error, Technical.

Error, Air Traffic System: (cited in Danaher, 1980) An operational error in which a failure of equipment, human, procedural, and/or other system elements, individually or in combination, results in less than the appropriate separation minima, as specified in the ATC Terminal and Enroute Handbooks and supplementary instructions, being provided to an aircraft receiving an air traffic service (DOT, 1973, p. 1).

Error, Forgetting: (BASI) Failing to check, set, or use a control at the proper time.

Error, Grievous: (McRuer, et al., 1980) A grievous error will involve an exceedence of safe operating tolerances.

Error, Human: (cited in McRuer, et al., 1980) An inconsistency with a predefined behavior pattern established by virtue of system requirements and specifications and the design of the equipment and procedures to meet those specifications.

Error, Human Error Causes: (McRuer, et al., 1980) Causes are external factors that induce undesirable deviations in human behavior, such as unexpectedly large or extreme disturbances, high workload, distractions, inaccurate or noisy information, illusions, equipment design deficiencies, and inadequate training.

Error, Human Error Sources: (McRuer, et al., 1980) Sources are internal to the human operator and their consequences should be measurable as changes from normal or ideal human behavior, which is consistent with system requirements.

Error, Reversal: See Error, Technical.

Error, Substitution: See Error, Technical.

Error, Technical: (AFP) An objectively inappropriate individual discreet action (error of execution). Examples are missing a radio call, being off altitude or airspeed, or improper switch or control operation. (May be influenced by a perceptual set, response set, or misleading environmental cues.)

> **Adjustment Error** - (AFP) Operating a control too slowly or too rapidly, moving a control or switch to the wrong position, or following the wrong sequence in operating several controls or switches.
>
> (BASI) Operating a control too slowly or too rapidly, moving a switch to the wrong position, or following the wrong sequence in operating several controls.
>
> **Forgetting Error** - (AFP) Failing to check, set, or use a control or switch at the proper time.
>
> **Reversal Error** - (AFP) Moving a control or switch in a direction opposite to that necessary to produce the desired result.
>
> (BASI) Moving a control in a direction opposite to that necessary to produce the desired result.
>
> **Substitution Error** - (AFP) Confusing one control or switch with another or failing to identify a control or switch when it was needed.
>
> (BASI) Confusing one control with another or failing to identify a control when it was needed.
>
> **Unintentional Activation** - (AFP) Accidently operating a control or switch.
>
> (Fitts and Jones, 1947) Inadvertently operating a control without being aware of it.

(BASI) Accidently operating a control.

Error, Unable to Reach a Control: (Fitts and Jones, 1947) Accident or near accident resulting from "putting head in cockpit" to grasp a control or inability to reach a control at all.

Error, Unintentional Activation: See Error, Technical.

Errors, Information Processing/Procedural: (Gerbert and Kemmler, 1985) Erroneous judgment, miscalculations, wrong decisions, and faulty design of action plan (e.g., deficient flight preparation, neglect of procedures or use of improper procedures, misjudgment of weather, continued application of VFR after entering IMC, faulty fuel management, and loss of geographic orientation). Mainly associated with following background variables: lack of proficiency, lack of procedural knowledge, difficulties of memory and recall, information overload, inadequate briefing, and short-term changes of flight plan.

Errors, Perception: (Gerbert and Kemmler, 1985) False utilization of objectively only partially present information (e.g., spatial disorientation, visual illusion, faulty identification, misjudgment of distances and heights, and too late or too early pull up or flare out). Errors are mainly associated with contradictory environmental cues or stimuli close to the threshold (e.g., restriction of visibility, camouflage of stimuli, and nonperceptibility of horizon).

Errors, Vigilance: (Gerbert and Kemmler, 1985) Missing or fragmentary uptake of objectively present information due to inattention, channelized, or shifted attention. Examples are omission of necessary actions, failure to maintain altitude, attitude, or airspeed; poor cross check; poor visual lookout; and failure to stay within aircraft's performance limits. Vigilance errors generally associated with intrapersonal conditions, such as nervousness, high tension, oversaturation of information channels, carelessness, and other background variables.

Event Proficiency: (AFP) Event proficiency (lack of) is considered a factor when the pilot attempting the mission element has (1) never done it before, (2) done it before but not recently, or (3) done it recently but for the first time. "Proficiency" and "currency" as defined by MAJCOM criteria are not necessarily synonymous, as the pilot's demonstrated ability to perform the task is the governing factor.

Evolved Gas Disorders: See Decompression Sickness.

Excessive Motivation: See Motivation, Anomalies of.

Exercise (Operational): (AFP) A period of enhanced operational activity to demonstrate readiness.

Expectancy (or Perceptual Set): (BASI) When a person expects to perceive certain environmental cues and tends selectively to search for those cues more actively than others. One extreme of this anomaly is when the expectancy is so strong that he perceives cues that in fact are not there; the other extreme is when he does not expect cues to the extent that he does not detect cues that are there.

Expectation: (AFP) A mental set in which environmental conditions are anticipated before their occurrence. This may lead to a perceptual or response set.

Experience Lack: (AFP) Lack of experience is a factor when the events during a mishap were caused by a pilot's lack of background in the type aircraft being flown (e.g., fighter, bomber, and cargo), the type mission being attempted (e.g., air to ground, air to air, and low level), or the role being performed (e.g., flight lead and IP). Whether or not the aircrew was "experienced" according to MAJCOM definitions, if his or her inexperience in the aircraft, mission, or role led to the mishap, this factor is assigned.

Face Time: (AFP) Time invested in increasing supervisory awareness of the individual (may be positive or negative.)

Factor: (Barnhart, et al., 1975) One of the elements that contribute to produce a result; a constituent.

Factor, Associated: (Barnhart, et al., 1975) An element that is present in the history of an anomaly and is pertinent to the occurrence under study, but does not fulfill the requirements of an enabling factor.

Factor, Enabling: (Barnhart, et al., 1975) An element that is present in the history of an anomaly and without which the anomaly probably would not have occurred.

Fascination: See Attention, Anomalies of.

Fatal Injury: (AFP) Any injury that results in death within 30 days of occurrence.

Fatigue: (BASI) The progressive decrement in performance ability due to prolonged mental or physical activity, extreme mental or physical activity, or sleep deprivation.

(AFP) The progressive decrement in ability due to prolonged or extreme mental or physical activity. Sleep deprivation, disrupted diurnal cycles, or life event stress may all play a role in producing a retrospectively unmeasurable but significant performance decrement.

Fatigue, Acute/Transient: (BASI) The type of fatigue associated with physical or mental activity between two regular sleep periods. Acute/transient fatigue is eliminated after a regular sleep period.

Fatigue, Cumulative/Chronic: (BASI) The type of fatigue resulting from an inadequate recovery from successive periods of acute/transient fatigue. One regular sleep period will not eliminate cumulative fatigue; however, several sleep periods and reduced interim activity will eliminate it.

Fatigue, Physical: (BASI) The effects of prolonged physical activity and/or the effects of brief but extreme physical activity, either of which taxed a person's physical capacity.

(AFP) The effects of prolonged physical activity or the effects of brief but extreme physical activity, either of which taxes a person's physical strength to the level of exhaustion.

Fatigue, Skill: (BASI) Defined as the deterioration in performance caused by work that demands persistent concentration and a high degree of skill. It is an insidious phenomenon associated with failure of memory, judgment, integrating ability, and presence of mind. Its effects may occur in conjunction with, and be accentuated by, other factors such as sleep loss.

Fatigue, Subjective: (BASI) The type of fatigue associated with the wearing effects of such psychosocial problems as unresolved conflicts, prolonged frustration, or constant worrying. Subjective fatigue is not eliminated by any number of sleep periods without first resolving the conflict or removing the frustrations.

Fight or Flight Response: (AFP) The heightened physiological state, automatically assumed by the body when faced with a crisis, to prepare for "fight or flight." This heightened physiological state may detract from rational processes and cause a person to overreact, overcontrol, or overlook significant cues.

Fitness: See Physical Condition.

Flight: (Barnhart, et al., 1975) A flight begins when an airplane's engines are started or when it is moved from its blocks for the purpose of undertaking a mission. It ends when the airplane is parked at its blocks and engine shutdown is complete or when it comes to rest following an impact with the surface of the earth.

Flight Clothing: (AFP) Items of clothing designed for inflight needs for protection and utility.

Flight Discipline: (BASI) Adhering to established procedures throughout the course of a flight. This includes not pursuing irrational or impulsive courses of action, actions that are inconsistent with established procedure, or actions not prebriefed.

Flight Path Angle: (AFP) The angle between the flight path of the aircraft and the horizontal.

Flight Recorder: (Annex 13) Any type of recorder installed in the aircraft for the purpose of complementing accident or incident investigation.

Flying Proficiency: (AFP) As opposed to event proficiency, this factor is assigned if limited recent flying time or sorties were considered to be a factor in the mishap.

Forgetting Error: See Error, Technical.

Foveal Visual Cues: (AFP) Visual stimuli falling within an approximately 6° cone from a person's normal sight line. Visual cues in this region are typically detected photopically (with cones). Foveal vision is mostly used for discerning fine detail, depth, and distance estimation and differentiating colors. Acuity falls to 0.25 (20/80) at 5° off foveal axis. Visual information more peripheral to this is thought to function heavily as a contributor to ambient orientation.

Free-Running: (Klein and Wegmann, 1980) Running autonomously under constant conditions, i.e., after removal of Zeitgeber.

Function: (Barnhart, et al., 1975) A distinctive process or activity; a useful activity. As used here, a specific class of behavior.

G-Adaptation Illusion: See Illusion, Kinesthetic.

G-Differential Illusion: See Illusion, Kinesthetic.

Gamesmanship: (AFP) (Also called careerism.) A form of manipulation of "the system" or its rules exerted by an individual for the sake of convenience or personal interest, often to the detriment of the intent of rules or guidance.

General Adaptation Syndrome: (AFP) The entire syndrome of psychological adaptive response in three stages:

1. Fight or flight response in alarm reaction—see flight or flight response.
2. Stage of resistance—stage of full adaptation to the stresses with consequent disappearance of symptoms (but with decreased coping reserve).
3. Stage of exhaustion—under severe or prolonged stress, finite coping ability is exceeded, resulting in reappearance of symptoms (burnout).

Geographic Misorientation: (AFP) The type of misorientation in which a person is correctly oriented with reference to the pitch, roll, and yaw axis (position in space), but not oriented in relation to known ground references or navigation fixes. (Lost or not spatially oriented.)

Geometric-Perspective Illusion: See Illusion, Visual.

Giant-Hand Illusion: See Illusion, Vestibular.

Greenwich Mean Time/GMT: (AFP) The mean solar time of the meridian of Greenwich, England used as the prime basis of standard time throughout the world. Expressed in hours GMT or hours Z (zulu phonetically).

Habit Pattern Interference: See Attention, Anomalies of.

Habit Pattern Substitution: See Attention, Anomalies of.

Hangover: (AFP) A popular term for the state of diminished mental and physiological capacity associated with a period following heavy alcohol intake (usually less than 24 hr).

Hazard: (ICAO-APM) Any condition, event, or circumstance that could induce an accident.

Histotoxic Hypoxia: See Hypoxia.

Horizon Misplacement: See Illusion, Visual.

Hull Loss: (cited in BCA, 1984) Damage due to an accident that was too extensive to repair or, for economic reasons, the aircraft was not repaired and returned to service.

Human Error: (cited in McRuer, et al., 1980) An inconsistency with a predefined behavior pattern established by virtue of system requirements, and specifications and the design of the equipment and procedures to meet those specifications.

Human Error Causes: (McRuer, et al., 1980) Causes are external factors that induce undesirable deviations in human behavior, such as unexpectedly large or extreme disturbances, high workload, distractions, inaccurate or noisy information, illusions, equipment design deficiencies, and inadequate training.

Human Error Sources: (McRuer, et al., 1980) Sources are internal to the human operator and their consequences should be measurable as changes from normal or ideal human behavior, which is consistent with system requirements.

Human Factors: (BASI) The study of the physical, physiological, psychological, psychosocial, and pathological limitations of man as he interfaces with his environment.

(AFP) The study of the human side of safety (i.e., the capacities and limitations of the human meeting environmental demands). (There is also HF engineering, referred to here under biomechanical, ergonomic, and cockpit design topic headings.)

Human Information Processing: (BASI) The mental process of perceiving incoming information from the environment, assessing its meaning, and deciding on an appropriate response. People have a limited capacity to process information that is received from different sources simultaneously, especially when the signals are of short duration and are not anticipated. Processing of such information can result in the loss of signals that are concurrent or follow closely on the processed signal.

Humor: (AFP) An affective response to an event where expectations differed grossly from actuality. It may be positive or negative depending on whether expectations were exceeded or not met.

Hypemic Hypoxia: See Hypoxia.

Hyperventilation: (BASI) Abnormally fast and/or deep respiration.

(AFP) Abnormally fast or deep respiration that results in sufficient change in blood pH to cause symptoms in an individual.

Hypoxia: (BASI) Oxygen deficiency in the tissues sufficient to impair function or performance. The most common form in aviation is hypoxic hypoxia due to a reduction of the oxygen tension in the inspired gas by ascent to altitude.

(AFP) Insufficient oxygen delivered to tissue, of which the brain is most sensitive.

Histotoxic Hypoxia - (BASI) Reduced cellular utilization of oxygen or inability of the body's tissues to accept oxygen from the blood (e.g., cyanide poisoning). Cyanide binds cytochrome oxidase and prevents oxygen utilization.

Hypemic Hypoxia - (BASI) Hypoxia resulting from reduced oxygen-carrying capacity of the blood. The basic causes are reduced concentration of hemoglobin (e.g., anemia caused by an iron deficiency, reduction in the amount of red blood cells as in hemorrhage, or failure of oxygen to saturate hemoglobin at a given PO2, such as carbon monoxide poisoning).

Hypoxic Hypoxia - (BASI) Oxygen deficiency in the blood, cells, and tissues caused by a decrease of the partial pressure of oxygen in the lungs or other conditions that reduce the diffusion of oxygen across the alveolar-pulmonary capillary membrane (e.g., asthma and pneumonia).

Stagnant Hypoxia - (BASI) Reduced blood flow to a tissue unit or failure of the blood to transport oxygen rapidly enough (e.g., shock, heart attack, and venous pooling from + Gz forces).

Illusion: (AFP) An erroneous interpretation of reality due to limitations of sensory receptors or the manner in which sensory information is presented or interpreted.

Illusion, Kinesthetic: (AFP) An erroneous perception of somatosensory stimuli to the ligaments, muscles, or joints of the body (proprioceptive).

(BASI) An erroneous perception of somatosensory stimuli to the ligaments, muscles, or joints of the body. Referred to as Somatosensory Illusion.

G-Adaptation Illusion: (AFP) An erroneous perception that motion has ceased after exposure to a sustained velocity. For example, movement in an elevator is only perceived at the beginning and end of the ascent or descent.

G-Differential Illusion: (BASI) An erroneously perceived aircraft attitude based on "seat of the pants" sensation. Without other sensory inputs, a 30° bank level turn feels the same as a 60° bank descending turn.

(AFP) An erroneous perception of aircraft attitude based on "seat of the pants" sensations. Without other sensory inputs, a 30° bank level turn feels the same as a 60° bank descending turn.

Illusion, Somatosensory: See Illusion, Kinesthetic.

Illusion, Vestibular: (BASI) (AFP) An erroneous perception orienting stimuli to the semicircular ducts or otolith organs of the vestibular apparatus.

> **Giant-Hand Illusion:** (BASI) (AFP) The erroneous sensation that controls will not respond to inputs, even with seemingly great effort, when the source of resistance is in fact the operator himself attempting to respond to conflicting sensory cues.

Illusion, Visual: (BASI) (AFP) An erroneous perception of stimuli to the visual system.

> **False Horizon Illusion** - (AFP) A visual illusion that occurs when ground lights are mistaken for stars or vice versa or when sloping terrain or clouds are mistaken for level horizon. A variant of this can occur at night on a range when the receding margins of an area lit by a falling flare create a false horizon effect.
>
> **Foreground Loss Illusion** - (AFP) The blending or blurring into the foreground of nearby objects when focusing on a distant object.
>
> **Geometric-Perspective Illusion** - (BASI) An erroneous perception of being nearer or farther away from an object than you actually are due to equating retinal image size to distance of familiar objects. For example, an 8 000 ft runway viewed from 1 000 ft above it may appear the same size as a 10 000 ft runway viewed from 1 500 ft; another example is the tendency to flare high on a wider than usual runway.
>
> **Horizon Misplacement:** (BASI) A visual illusion that occurs when ground lights are mistaken for stars or vice versa or when sloping terrain or clouds are mistaken for the horizon.
>
> **Vestibulo-Ocular** - (AFP) An erroneous and pathological vestibularly generated sensation of spinning that will affect visual interpretation of the environment (possibly inducing nystagmus).

Inactive: See Physical Condition.

Inattention: See Attention, Anomalies of.

Incident: (Annex 13) An occurrence, other than an accident, associated with the operation of an aircraft that affects or could affect the safety of operation.

(BASI) ANR 270 defines an incident as: "An occurrence, other than an accident, associated with the operation of the aircraft that affects or could affect the safety of operation of the aircraft." For the purpose of uniformity with ICAO and other member states, Australia also complies with the definitions given by ICAO in Annex 13.

(AFP) An occurrence other than an aircraft mishap, associated with the operation of an aircraft, that adversely affects or could affect the safety of operations.

(Barnhart, et al., 1975) An unwanted occurrence less serious than an accident, which involves any of several specific classes of occurrence:

Flight control system malfunction or failure; inability of a flightcrew member to perform his duties because of injury or illness; turbine engine rotor failures of certain types; inflight fire; and aircraft collide in flight.

Information - Mis: (BASI) When necessary information in written or oral instructions was omitted, incorrect, impractical, or vague.

Injury: (BASI) Annex 13 defines serious injury as:

An injury that is sustained by a person in an accident and (1) requires hospitalization for more than 48 hr, commencing within 7 days from the date the injury was received; (2) results in a fracture of any bone (except simple fractures of fingers, toes, or nose); (3) involves lacerations that cause severe hemorrhage, nerve, muscle, or tendon damage; (4) involves injury to an internal organ; or (5) involves second- or third-degree burns or any burns affecting more than 5% of the body surface.

Note: For statistical uniformity only, an injury (sustained in the accident) resulting in death within 30 days of the date of the accident is classified as fatal injury by ICAO.

Annex 13 includes the following in the definition of an accident: a person is fatally or seriously injured as a result of direct exposure to jet blast.

Injury, Serious: (Annex 13) An injury that is sustained by a person in an accident and (1) requires hospitalization for more than 48 hr, commencing within 7 days from the date the injury was received; (2) results in a fracture of any bone (except simple fractures of fingers, toes, or nose); (3) involves lacerations that cause severe hemorrhage, nerve, muscle, or tendon damage; (4) involves injury to any internal organ; or (5) involves second- or third-degree burns or any burns affecting more than 5% of the body surface.

Insight: (AFP) Awareness of one's own capabilities and relationship to various environmental circumstances.

Internalized Unit Values: (BASI) (AFP) A value system in which a person has taken the values, motives, and prioritized goals of the unit as his own. Such a person is referred to colloquially as a "team player."

Investigation: (Annex 13) A process conducted for the purpose of accident prevention that includes the gathering and analysis of information, the drawing of conclusions, including the determination of cause(s); and, when appropriate, the making of safety recommendations.

Investigator-In-Charge: (Annex 13) A person charged, on the basis of his qualifications, with the responsibility for the organization, conduct, and control of an investigation.

Note: Nothing in the above definition is intended to preclude the functions of an investigator in charge being assigned to a commission or other body.

Job Satisfaction: (BASI) (AFP) A person's subjective evaluation of the extent to which he/she is performing and progressing satisfactorily in the occupation of his/her choice and that meets his/her "professional need."

Judgment: (BASI) Assessing the significance and priority of informational data from the environment in terms of how they relate to the task at hand. The result of this process forms the basis on which decisions are made. Assigned when an individual is faced with a choice and the decision, or lack of decision, subsequently proves to be wrong and results in an occurrence. Judgment involves a mental reasoning process requiring an assessment of options rather than mechanical skills or the assessment of speeds, distance, and the like.

(AFP) Assessing the significance and priority of information from the environment in terms of how they relate to the overall task at hand. The exercise of this process forms the basis on which subsequent technical decisions are made.

> **Judgment Delay** - (BASI) Failure to assess the significance and priority of information from the environment in a timely manner, assuming adequate quality and quantity of information, due to an anomaly of attention or motivation.
>
> **Judgment, Poor** - (BASI) Failure to realistically assess the significance and priority of information from the environment, assuming adequate quality and quantity of information, due to an anomaly of attention or an anomaly of motivation.

Kinesthetic Illusion: See Illusion, Kinesthetic.

Knowledge Lack: (AFP) When a pilot was adequately exposed to the information needed to perform the mission element but did not absorb it, lack of knowledge is considered a factor. Lack of knowledge implies no deficiency in the training program, but rather the failure of the pilot to absorb or retain the information (exposure to information at a point in the past does not imply "knowledge" of it).

Landing Phase: (AFP) From the missed approach point until touchdown for an instrument approach; from crossing the runway threshold until touchdown for a visual approach. A go-around is considered part of the landing phase if it occurs after the missed approach point for an instrument approach or after crossing the runway threshold for a visual approach. After touchdown, a touch-and-go is considered a takeoff.

Law of Exception: (AFP) In the investigation of aircraft mishaps, the principle according to which, if all concrete or provable causes have been ruled out, it is concluded that the operative cause was one based on history of the particular aircraft or perhaps a typical or logical operator input.

Learning: (BASI) Long-term adjustments to a person's behavior as a result of reinforcement and practice. These adjustments may be either physical or mental.

(AFP) Adjustments to a person's behavior or thinking as a result of internalization of information. It is observed through either manual skill or vocabulary. This process is less efficient under the extremes of stress, whether too little or too great.

> **Learning Rate** - (AFP) The relative efficiency with which new information is acquired and relatively permanent adjustment made in one's behavior or thinking.
>
> **Learning Reinforcement** - (AFP) The activity of recalling and reviewing information or experiences to retain them for use in applied situations.
>
> (BASI) The requirement, over time, to recall and review experiences in order to retain them in long-term memory.
>
> **Learning Transfer** - (AFP) The ability of a person to apply, in present or future situations, the related experience (or less significantly, knowledge) acquired in past situations.
>
> (BASI) The ability of a person to apply in real world situations the experience acquired in learning situations.

Life Change Events: (BASI) Death of spouse, divorce, marital separation, detention in jail, death of a close family member, personal injury or illness, marriage, being fired from work, marital reconciliation, change in health or behavior of family member, pregnancy, major business readjustment (major job readjustment), sexual difficulties, change in financial state, death of a close friend, change to a different line of work, change in number of arguments with spouse, mortgage or loan greater than $40 000, foreclosure of mortgage or loan, gaining a new family member (by birth, adoption, or someone moving in), son or daughter leaving home, change in responsibilities at work, in-law troubles, outstanding personal achievement, wife beginning or ceasing work, beginning or ceasing formal schooling, change in living conditions, change in personal habits, troubles with boss, change in residence, change in working hours or conditions, changing to a new school, change in recreational habits, mortgage or loan less than $40 000, change in sleeping habits, change in eating habits, change in family get-togethers, vacation, and minor violation of the law.

Lighting Regimen: (Klein and Wegmann, 1980) Schedule of light and/or darkness exposition; L = light, D = dark, LL = continuous light, and DD = continuous dark.

Major Injury: (AFP) An injury that (1) requires hospitalization for more than 48 hr, commencing within 7 days from the date the injury was received; (2) results in a fracture of any bone (except simple fractures of fingers, toes, or nose); (3) causes severe hemorrhages, or severe nerve, muscle, or tendon damage; (4) involves any internal organ; or (5) involves second- or third-degree burns or any burns affecting more than 5% of the body surface.

Mandelbaum or Screen Porch Effect: (BASI) Any visual stimulus coincident with the dark focus traps the focus and degrades acuity beyond. The dark focus is the relaxed accommodation distance. Dark focus distance in the normal emmetrope averages about 1m, is shorter for myopes and greater for hyperopes. Should this distance coincide with that between eye and windscreen, any visual stimulus on the windscreen, such as dirt, moisture, gun-gas residue, crazing, sunglare, reflections, or bug spatter, could trap the focus and impair visual acuity beyond. In addition to the hazard of no perception, the loss of definition and accommodative minification of objects seen may convey the false impression of height or distance.

Maximum Mass: (Annex 13) Maximum certificated takeoff weight.

Maximum Weight: See Maximum Mass.

Medical Profile: (Stoklosa, 1983) Involves the predisposing physiological and sensory variables that could affect performance. Includes general health, sensory acuity, drug or alcohol ingestion, and fatigue. Consideration also includes physical condition, nutrition, medication, sleep cycle, and circadian rhythm.

Memory: (AFP) The mental activity of recalling past experience. Experience includes any information a person receives through any means, any cognitive functions he/she performed on that information, and any he/she response made as a result of it.

> **Long-Term Memory** - (BASI) The recall of information or events after a period in excess of several minutes after its occurrence (days, months, and years).
>
> **Short-Term Memory** - (BASI) The recall of information or events within 1 min of its occurrence.
>
> **Working Memory** - (AFP) That experience or knowledge that is immediately available. It is usually sensory rather than verbal.

Metacontrol: (McRuer, et al., 1980) The human's activity-supervising control, transcending the various directly involved systems such as the perceptual, central, and neuromuscular systems (from Greek "meta" meaning "involved with changes").

Microburst: (AFP) A localized but very severe weather phenomenon resulting in dramatic and abrupt changes in wind direction and velocity.

Mishap Factors: (AFP) An attempt to explain and catalog at HQ AFISC why "primary causes" occurred. The factors defined are not mutually exclusive but rather are often interrelated and in some cases, influence one another. As a result, most mishaps involve multiple mishap factors.

Mishap Type Categories: (AFP) The type mishap is a mishap category assigned by the Reports and Analysis Division at AFISC. Type mishap does not necessarily imply "cause," but rather 1 of the natural mishap groupings that emerged from a comprehensive study of 3 400 mishaps done in 1975.

Cargo Delivery - (AFP) Mishaps directly involving cargo delivery problems (LAPSES, etc.) comprise this category.

Collision With the Ground - (AFP) This mishap category is assigned when a pilot flies the aircraft into the ground without being forced to by a material failure. A material failure may exist, but if adequate control and power were available to avoid the terrain, this category is assigned.

Control Loss - (AFP) Control loss is a mishap category assigned when a pilot stalls, spins, departs, or otherwise exceeds the aircraft's flyable angle of attack. Mishaps where the pilot fails to cope with the aerodynamic characteristics of the aircraft (such as putting it in a position from which recovery is impossible) are included in this category, but flight control or autopilot malfunctions are not.

Flameout (Pilot) - (AFP) This mishap category involves pilot-induced flameouts for any reason. Inadvertent or intentional shutdown, fuel mismanagement, and flying out of the engine's tolerable envelope are examples of this type mishap.

Flight Controls, Landing Gear, Engine, Fuel System, Etc. - (AFP) Mishaps that involve failure of aircraft systems are categorized by the system that failed. The rationale for this is twofold. First, our material failure prevention efforts are better served by isolating those mishaps where an aircraft system failure precipitated an aircrew error from those involving aircrew error only. Second, we believe that given enough system failures, the potential for an aircrew error increased, an error the pilot would not have made had the system not failed to begin with. Mishaps involving aircrew error preceded by an unrelated system failure are categorized by the type of error made.

Midair Collision - (AFP) Mishaps that involve aircraft hitting each other during flight (starting takeoff roll to end of landing roll) are categorized as midair collisions, regardless of whether the pilot or a flight-control failure was the cause.

Ops Other - (AFP) Mishaps that involve the aircrew but do not fit any of the major operations types are classified by HQ AFISC as "ops other." Examples are a pilot who perceives a problem that does not really exist and ejects from a perfectly good airplane or a pilot who has a taxi mishap because he or she did not notice brake hydraulic systems were turned off.

Range - (AFP) This mishap category is assigned when a pilot fails to recover from an air-to-ground ordnance delivery pass or if a pilot loses control while engaged in the activity of delivering ordnance. Again, the activity is the governing factor rather than the location and mishaps that occur during actual or simulated ordnance delivery are categorized as range mishaps whether or not the aircraft crashed on range property.

Takeoff or Landing - (AFP) Mishaps that occur during takeoff or landing and that do not involve any material failure are categorized as takeoff or landing mishaps. These mishaps must occur on takeoff before configuring for climb or during landing after the pilot begins to flare or align the aircraft with the runway.

Mishap, Antecedent Events: (AFP) Those events or conditions that occurred before the demonstration of intent for flight but that relate to the conditions making the mishap more likely (e.g., fatigue and get-home-itis, etc.).

Mishap, Maneuver: (AFP) A subelement of the mishap phase of flight described by the sequence of tasks required to perform the event (e.g., turn out of traffic, formation crossover, and egress from a weapons delivery pass).

Mishap, Phase of Flight: (AFP) The phase of flight being performed at the point of the mishap.

Mishap, Point of: (AFP) That point in the mishap sequence of events at which no preventive or evasive action by the operator would have avoided the mishap. (Not always the point of impact.)

Misperception: See Perception.

Misplaced Motivation: See Motivation, Anomalies of.

Mission: (Barnhart, et al., 1975) This term refers to the composite of pilot and vehicle functions that must be performed to fulfill a given set of operational requirements. Those operational requirements impose the boundaries on expected operation during a flight.

Mission Demands: (AFP) The relative degree of workload requirements inherent in different types of missions as a function of the number or difficulty of mission events.

Mission Requirement Factors: (Gerbert and Kemmler, 1985) Low-level flight, formation flight, tactical exercise, terrain following flight, information overload, cross country flight, and approach landing.

Mistake: (Norman, 1981) It is a mistake if the intention is not appropriate.

Modeling: (AFP) Behavior exhibited by peers and supervisors in the context of its influence on learning in an individual observing them.

Mood: See Affective States.

Morale: (AFP) A mindset consisting of a set of subjective assessments of well being relative to factors an individual perceives as important (which may be characterized by confidence and optimism or by bitterness and pessimism). Morale suffers when unnecessarily high or vague expectations are created because subsequent actual experience cannot measure up to them.

Motivation: (BASI) A value system that operates in determining the direction of an individual's behavior toward an end or goal. That which stimulates and causes an individual to act. Excessive motivation or undermotivation may degrade one's ability to make rational judgment or decisions.

(AFP) A person's underlying or internalized drive consisting of a prioritized value system that influences his or her behavior and thought.

Motivation, Anomalies of: (AFP) Characteristics of a person's value system that may result in unsafe acts.

> **Excessive Motivation** - (AFP) Attributing a higher value to successfully performing the mission than actually warranted by the importance of the mission. Past failures often create this higher than desirable will to succeed, especially if the failures resulted in criticisms. Overmotivation has also resulted from overemphasis on competition, with the attendant underemphasis on training.
>
> (BASI) Attributing a higher value to successfully performing the flight than actually warranted by the importance of the mission.
>
> **Misplaced Motivation** - (BASI) The factors influencing a person's selection of course of action that were superficial to or not related to the objective requirements of the flight.
>
> **Undermotivation** - (BASI) Attributing a lower value to successfully performing the flight than actually warranted by the importance of the mission.

Motivational Exhaustion: (AFP) The type of exhaustion associated with the wearing effects of such psychosocial problems as unresolved conflicts, prolonged frustration, or constant worrying. It is not eliminated by any number of sleep periods without first resolving the conflict or removing the frustrations. (Also called subjective fatigue or burnout.)

Myopia, Space: (BASI) Space myopia is a condition that reduces the ability of the eyes to focus due to the lack of objects to focus on. Relatively "empty" visual fields occur when you are flying at night, at high altitudes, over water or snow, or during a hazy day. Also, clouds have surprisingly little effect as stimuli for distant focusing. Under such conditions, the eye relaxes and allows the lens to seek an intermediate curvature that requires no particular focusing effort. This relaxed state is known as the dark focus (about 1m to 2m).

Near Midair Collision: (NASA TM 81225) A near midair collision is defined for the purposes of this study as a conflict between two aircraft in which the reporter's estimate of miss distance is less than 500 ft, evasive action is taken to avoid a collision, or it is reported that there was insufficient time to take evasive action.

Noise, Vibration, and Buffet: (BASI) The performance of certain tasks may be adversely affected if performed in conditions of specific types and patterns of noise or excessive vibration or buffeting. The degree of interference with task performance will vary with the nature of the task being performed.

Nonperception: See Perception.

Operational Profile: (Stoklosa, 1983) Potentially influencing operational and procedural factors. Includes training, experience, operational procedures, and company management policies. Looks at assessing the relation of such issues as habit patterns, information aids, and company personnel practices to operator performance.

Operator: (Annex 13) A person, organization, or enterprise engaged in or offering to engage in aircraft operation.

(AFP) The person in control of the aircraft at the point of the mishap. Other personnel involved in the mishap sequence of events are considered part of the operator's equipment or support.

Organizational and Supervisory Factors: (Gerbert and Kemmler, 1985) Time pressure before flight, short-term changes in flight order, inadequate briefing, supervisory pressure, and insufficient crew coordination.

Oscillator: (Klein and Wegmann, 1980) Mechanism generating a rhythm.

Overcommitment: (AFP) A response set in which a person commits to a task for which he or she is knowingly ill prepared and that presses pilots and their aircraft beyond reasonable limits ("taking a chance" or "pressing").

Overconfidence: See Confidence.

Overtasking: (AFP) When a pilot is tasked to perform a mission element he or she is not capable of performing or put in a situation where success requires that person to exceed his or her capabilities, the pilot is considered to be "overtasked." Overtasking normally involves supervisors, schedulers, or flight leaders and implies some need for supervisory awareness of the variable capacities of those being tasked.

Peer Pressure: (AFP) A motivating factor stemming from a person's perceived need to meet peer expectations. Peers may or may not express those expectations.

Perception: (BASI) The detection and interpretation of transthreshold information from the environment by one or more of the senses.

> **Delayed Perception** - (BASI) (AFP) Failure to detect information in a timely manner due to an anomaly of attention or motivation.

Misperception - (BASI) Failure to detect or correctly interpret information due to an inappropriate perceptual set.

Nonperception - (BASI) Inability to detect information from the environment because of sensory limitations and the manner in which the information is presented.

(AFP) Inability to detect cues from the environment because of sensory limitations or the manner in which the cues are presented. (Possibly a cockpit design concern.)

Perception, Anomalies: (BASI) There are several anomalies of perception that singly or in concert play a part in deceiving the pilot:

Nonperception - (BASI) Failure to see an obstruction that blends into its background due to similarities of texture, coloring, or lack of contrast. Such foreground masking is enhanced by lighting conditions that reduce or eliminate shadows, as with a high sun angle, beneath an overcast, or in haze. This camouflage applies not only to the ground and ground objects, but to vegetation and man-made structures as well.

Height Estimation - (BASI) Accuracy in gauging altitude or terrain clearance may be quite difficult. Height estimation involves one or more of the following factors:

Perspective - (BASI) A function of size constancy, the appreciation of relative size of some object of known dimension to its surroundings. Confusing the size of the "known" object(s) by which perspective is gained can create a dangerous trap. For example, pilots accustomed to flying over forested ranges with tall trees or large rocks may unwittingly be drawn to low altitudes over ranges peppered with short trees and small rocks. A low sun angle can produce long shadows from short trees and create the same effect. Switching from a range with 3-ft sage brush to a range with 1-ft sage brush demands an immediate recalibration of the visual system. The type of terrain affects perspective. Perspective is essentially absent over relatively flat and featureless terrain. It may be impossible to gauge height over water, snow, dry lake bed, or desert. Desert, with its subtle, insidious elevation changes and its propensity for disguising obstructions, is particularly treacherous.

Definition - (BASI) Fine definition or clarity conveys closeness, whereas anything that fuzzies definition conveys a false impression of distance, (e.g., haze, fog, blowing snow, drizzle, dust, or twilight).

Motion Parallax - (BASI) The relative motion of near objects to those distant. Motion parallax is a function of ground speed and distance as well as height; the faster, the lower.

Perception, Delayed: See Perception.

Perception, Intellectual: (AFP) The individual's general interpretation of surroundings, events, or conditions. This is influenced by such factors as the personality, motivation, and the expectations of the person.

Perception, Mis: See Perception.

Perception, Non: See Perception.

Perception, Sensory: (AFP) The detection of transthreshold cues from the environment by one or more of the senses.

Period: (Klein and Wegmann, 1980) Time after which a phase of an oscillation recurs; in a looser sense also used for phase angle.

Peripheral Visual Cues: (AFP) Visual stimuli falling outside of an approximately 6° cone from a person's normal sight line. Visual cues in this region are typically detected scotopically (with rods). Peripheral vision detects gross movement and even if not consciously recognized, contributes to ambient orientation.

Phase Angle: (Klein and Wegmann, 1980) Value of the time scale (abscissa) corresponding to a phase of a rhythm; given in fractions of the period (units of time and angular degrees or radians).

Phase of Flight, Mishap: See Mishap, Phase of Flight.

Phase Shift: (Klien and Wegmann, 1980) Abrupt or gradual displacement of a rhythm along the time scale.

Physical Condition: (BASI) The relative physical condition of a person in terms of the extent of a regular rigorous exercise program and/or physically active lifestyle.

(AFP) The relative physical state of a person in terms of the extent of a regular rigorous exercise program or a physically active lifestyle.

> **Athletic** - (AFP) At least 6 hr of rigorous exercise per week and a physically active lifestyle.
>
> **Above Average** - (BASI) At least 2 hr of rigorous exercise per week or a very active physical lifestyle.
>
> **Active** - (AFP) At least 2 hr of rigorous exercise per week and a physically active lifestyle.
>
> **Average** - (BASI) Less than 1 hr of rigorous exercise per week or an intermittently physically active lifestyle (e.g., sports and yardwork).

Inactive - (AFP) Less than 1 hr of rigorous exercise per week or an intermittently physically active lifestyle.

Physical Factors: (Gerbert and Kemmler, 1985) Poor actual physical fitness, fatigue.

Physical Fatigue: See Fatigue, Physical.

Physical Strength: (BASI) A consensus judgment of peers as to the relative physical strength of a person.

(AFP) In the absence of objective measurement, this may be a subjective judgment of peers as to the relative physical strength of a person.

Physical Task Saturation: (BASI) A situation in which the number or difficulty of tasks to perform in a compressed time period exceeds a person's physical capacity to perform all of them.

(AFP) A situation in which the number or difficulty of manual tasks to perform in a compressed time period exceeds a person's capacity to perform all of them (may be a result of poor crew coordination).

Pilot's Proficiency Factors: (Gerbert and Kemmler, 1985) Low overall flying experience, insufficient training, lack of familiarity with aircraft, and lack of training with regard to specific events and procedures.

Point of Mishap: See Mishap, Point of.

Poor Decision: See Decision.

Poor Response: See Response.

Postanomaly: (Barnhart, et al., 1975) This term includes all activities related to the conduct of a mission that occur after an anomaly and prior to the end of a flight.

Postflight: (Barnhart, et al., 1975) This term includes all activities related to the conduct of a mission that take place subsequent to a flight. It includes postcrash rescue and survival efforts.

Preanomaly: (Barnhart, et al., 1975) This term includes all relevant activities from the beginning of a flight to the occurrence of an anomaly.

Preflight: (Barnhart, et al., 1975) This term includes all activities relevant to a mission that occur prior to the beginning of the flight.

Preconscious Level: See Awareness, Level of.

Preliminary Report: (Annex 13) The communication used for the prompt dissemination of data obtained during the early stages of the investigation.

Press-On-Itis: (BASI) Assigned when an individual sees a perceived need to continue a flight beyond personal, human, equipment, or environmental limits. The pilot confers on the flight higher priority than really exists. There are various reasons for pressing: self-imposed pressure, peer pressure, command pressure, overconfidence, etc.

Prioritized Significant Events and Conditions: (AFP) A dynamic, cognitive hierarchy of perceived environmental factors that serves to organize what tasks need to be performed, and in which order, to manage the immediate situation.

Procedures Inadequacy: (AFP) When the procedures for accomplishing a task are clearly inadequate, this factor is assigned. For example, procedures for determining the adequacy of a strafe pit were lacking, and the resulting increased ricochet density caused a destroyed aircraft due to 22 mm engine FOD.

Processing: (Barnhart, et al., 1975) The act of making a decision.

Professional: (AFP) A term applied to a vocation that implies autonomy, group identity, altruism, extraordinary skill, and exercise of judgment.

Psychological Factors: (Gerbert and Kemmler, 1985) Psychic stress prior to flight, excessive motivation to succeed, high tension and arousal level during flight, lacking awareness of risk, overconfidence, and task oversaturation.

Radar Approach Control Facility: See RAPCON Facility.

Rain Check: (AFP) The decision not to carry out a given act after appropriate risk analysis.

Range of Oscillation: (Klein and Wegmann, 1980) Difference between maximum and minimum value of a rhythm within a period.

Range Phase: (AFP) The time when the aircraft enters the area designated for practicing or conducting mission activities until departure. This may be in a low-level route, military operating area, gunnery range, warning area, refueling track, etc.

RAPCON Facility A: (AFP) A terminal ATC facility that uses radar and nonradar capabilities to provide approach control services to aircraft arriving, departing, or transiting airspace controlled by the facility.

Re-entrainment: (Klein and Wegmann, 1980) Transient state of an endogenous rhythm after a phase shift of its Zeitgeber with the tendency to achieve the previous constant phase relationship again.

Reaction Time: (BASI) An inherent perceptual limitation that requires an individually specific amount of time for information processing before action is taken.

(AFP) An inherent human limitation that requires an individual a task-specific amount of time for information processing before action is taken. It includes the elements of perception, interpretation, judgment, decision, and response. Execution time required at any step may depend on experience, attention focus, fatigue, etc.

Regular Sleep Period: (AFP) The period of a 24-hr day that a person usually spends in continuous sleep. This must be on home time.

Resources: (BASI) When adequate manpower, finances, equipment, knowledge, skill level, or training were not provided to properly accomplish the task.

Response: (BASI) The execution of a selected course of action. This may include taking no action if that was the selected response.

(AFP) The execution of a selected course of action. This may include taking no action if that was the decision made.

> **Delayed Response** - (BASI) The execution of a selected course of action due to cognitive or physical task saturation, an anomaly of attention, an anomaly of motivation, or lack of sufficient procedural knowledge.
>
> **Poor Response** - (BASI) Ineffective execution of a selected course of action due to cognitive or physical task saturation, an anomaly of attention, an anomaly of motivation, or lack of sufficient procedural knowledge.

Response Set: (BASI) Expectations that predispose a person to a certain course of action.

(AFP) A cognitive or mental framework of expectations that predispose a person to a certain course of action regardless of the environmental cues.

Resynchronization: (Klein and Wegmann, 1980) Transient state of a rhythm after a phase shift of the synchronizing rhythm, lasting until the previous constant phase relationship between the two rhythms is achieved again.

Reversal Error: See Error, Technical.

Rhythm: (Klein and Wegmann, 1980) Changes of a biologic variable recurring systematically with detectable periods; normally superimposed with random noise.

Risk: (ICAO-APM) The consequence of accepting a hazard.

Routine action: (McRuer, et al, 1980) A well-practiced task carried out in familiar surroundings by skilled operators.

Safety Recommendation: (Annex 13) A proposal of the investigating authority of the state conducting the investigation, based on information derived from the investigation, made with the intention of preventing accidents or incidents.

Self Preflight: (AFP) Personal self-assessment that includes physiological and mental readiness in light of specific planned mission objectives.

Self-Image: (AFP) This factor has been assigned by HQ AFISC in mishap reviews where the pilots involved persistently appeared to perceive themselves as far better, smarter, or more capable than they were.

Sensorimotor/Handling Errors: (Gerbert and Kemmler, 1980) Deficiencies in timing and adjustment of simple/discrete and complex/continuous motor activities as well as perceptual-motor reversal and confusion. Examples are delayed actions and reactions, poor control precision and multiple limb coordination, and confused or inadvertent activation of controls. These are mainly associated with intrapersonal conditions, such as tension, nervousness during flight, "fear of failure," lack of confidence, and excessive motivation to succeed.

Serious Injury: See Injury, Serious.

Service Ceiling: (G-10 TSI) (AFP) The height above sea level, under standard atmospheric conditions, at which a given airplane is unable to climb faster than 100 ft/min.

Short-Term Memory: See Memory.

Significant Others: (BASI) Those individuals in whom a person has a vested emotional interest such as family members, close friends, or identity figures.

Simulator: (AFP) A device or facility that provides a representation of some essential elements of a system out of their normal setting in such a manner that the representation is a valid analog of the system to be used in the training and maintenance of pilots' skills. These are of limited value in mishap reconstruction and such results must be guardedly interpreted.

Situational Awareness: (AFP) Keeping track of the prioritized significant events and conditions in one's environment. Confusion here may affect the sequence or priority of tasks to be performed. ("Getting behind the power curve.")

Skill or Technique Lack: (AFP) Skill or technique deficiencies are considered a factor when a pilot either lacks the required motor skills or uses an improper technique to perform the task attempted.

Slip: (Norman, 1981) It is a slip if the action is not what was intended.

Spatial Disorientation: (BASI) When the aviator fails to sense correctly the position, motion, or attitude of his aircraft or of himself with respect to the Earth's surface and the gravitational vertical as a result of conflicting sensory information.

Spatial Disorientation (Type III) - (AFP) Lack of knowledge as to orientation in space due to the inability to detect orienting cues, as in a rapidly spinning or tumbling aircraft. In this situation the lack of orientation is recognized, but there are neither usable cues nor a cognitive expectation of true orientation. (Also called vestibulo-ocular disorganization.)

Spin: (cited in Aderet and Tal, 1984) A sustained spiral descent of fixed-wing aerodyne with angle of attack beyond stalling angle. Theoretically a spin can be described as a rapidly descending maneuver in which the airplane rotates about its vertical axis with unequal lift on its wings.

Stability, Aerodynamic: (AFP) The inherent flight characteristic of an aircraft tending to restore it to its original condition when disturbed by an unbalancing force or moment.

Stagnant Hypoxia: See Hypoxia.

Standard Sortie: (AFP) One of a set of preplanned, commonly flown flight itineraries in use by a squadron.

State of Manufacture: (Annex 13) The state(s) responsible for the certification as to the airworthiness of the prototype.

State of Occurrence: (Annex 13) The state in the territory of which an accident or incident occurs.

State of Registry: (Annex 13) The state on whose register the aircraft is entered. Note: In the case of the registration of aircraft of an international operating agency on other than a national basis, the states constituting the agency are jointly and severally bound to assume the obligations which, under the Chicago Convention, attach to a state of registry. See, in this regard, the Council Resolution of 14 December 1967 on Nationality and Registration of Aircraft Operated by International Operating Agencies (DOC 8722-C/976).

State of the Operator: (Annex 13) The state in which the operator has his principal place of business or, if he has no such place of business, his permanent residence.

State-Dependent Memory: (AFP) A learning anomaly in which a learned task is best remembered when the conditions exist that were present at the time of learning. Thus, procedural "knowledge" gained in a classroom setting may not be recalled in an operational setting.

Strength: (BASI) The strength required to perform a task may be assessed as excessive due to either peculiar flight conditions, design features of the aircraft, or the condition of the individual.

Stress: (BASI) A certain level of stress is a normal part of day-to-day living. Coping mechanisms are developed by the individual to handle variations in stress levels and these adaptive mechanisms can be overtaxed in certain circumstances. This may be related to one's personal life, family life, work environment, etc.

> **Mission Stress:** (BASI) If the conditions surrounding a mission generate excessive stress, this is considered a factor. These conditions are often present during deployments, checkrides, exercises, and other high-visibility missions.
>
> **Personal Stress:** (BASI) Personal stress may be a factor if a pilot has unusual or severe personal problems. Although difficult to assess the extent to which these problems might influence his or her performance, personal stress may be considered a factor if severe problems exist.
>
> (Barnhart, et al., 1975) Any element in the environment of man that evokes a response.

Stress, Acute Reactive: (Green, 1985) The "fight or flight" syndrome of increased autonic activity in the face of threat is well known and recognized, and when confronted with an aircraft emergency a pilot is likely to experience such acute reactive stress.

Stress, Environmental: (Green, 1985) For a military pilot this can mean noise, vibration, heat, cold, and even, possibly, mild hypoxia. Civil pilots likely to be affected by sleep deprivation.

Stress, Life: (Green, 1985) Stress produced by recent life events, such as bereavement or divorce, or less obviously traumatic occurrences such as moving house or changing jobs.

Stress, Other: (BASI) A degraded capability to perform specified tasks when faced with psychosocial stresses such as family, financial, legal, religious, death, or illness of significant others.

Stress, Task Related: (BASI) A heightened psychophysiological response state experienced by a person when he/she perceives that the workload demands of the task may exceed his/her capabilities and that the successful completion of the task is thus threatened. In such a situation, a person's adaptive mechanisms become severely taxed. Problems arise when his adaptive mechanisms are taxed to the point that they collapse and the person is unable to meet the workload demands of the task.

Subconscious Level: See Awareness, Level of.

Subjective Fatigue: See Fatigue, Subjective.

Substantial Damage: (cited in BCA, 1984) Except as provided in the second sentence of this paragraph, substantial damage means damage or structural failure that adversely affects the structural strength,

performance, or flight characteristics of the aircraft and that would normally require major repair or replacement of the affected component. Engine failure damage limited to an engine, bent fairings or cowling, dented skin, small punctured holes in the skin or fabric, damage to landing gear, wheels, tires, flaps, engine accessories, brakes, or wingtips are not considered "substantial damage."

Substitution Error: See Error, Technical.

Subsystem: (Barnhart, et al., 1975) A complex of aircraft components, such as electrical system, hydraulic system, etc.

Subthreshold: See Threshold (2).

Supervisory Pressure: (BASI) A motivating factor stemming from a person's need to meet perceived supervisory expectations based on a perceived threat to the subordinate's interests.

(AFP) A motivating factor stemming from a person's need to meet perceived supervisory expectations whether or not those expectations are overtly expressed.

Suprathreshold: See Threshold.

Synchronization: (Klein and Wegmann, 1980) Steady state in which rhythms run with equal periods and constant phase relationships.

Synchronizer: See Zeitgeber.

System, Aviation: (Barnhart, et al., 1975) The total complex of persons, components, and facilities involved in the movement of persons and cargo by air.

Takeoff Phase: (AFP) Runway hold line to airborne and past the field boundaries (until configuring for climbout).

Task: (McRuer, et al., 1980) An activity at the functional interface of the human operator and the individuals, objects, and environments with whom or which he interacts. Further specified as a goal- or criterion-oriented work increment involving application of a skill or set of skills by the human operator.

Task Design: (BASI) Properly balanced allocation of tasks for both man and machine to prevent overload. This is dependent on the realistic flight based on the capabilities and limitations of the man and the machine (proper SOPs).

Task Profile: (Stoklosa, 1983) Focuses on the specific work performance events and variables of the accident scenario. Includes task information, task components, task-time relation, and workload. Collect data related to information sources, task alternatives, attention, workload demands, and time constraints.

Taxi Phase: (AFP) From engine start to runway hold line and from clearing the active runway to having parked the aircraft.

Tech Data Inadequacy: (AFP) Mishaps involving maintenance or design technical data that are clearly deficient are assigned this factor. A lack of description of generally known procedures (such as buttoning up panels when through or using left rudder if the aircraft drifts right on landing) is not considered an inadequacy.

Technical and Design Factors: (Gerbert and Kemmler, 1985) Malfunction of technical subsystems, inadequate cockpit design, and personal equipment deficiency.

Technique, Poor: (BASI) Operation, workmanship, or mechanical skills below that which can be reasonably expected from a person with equal training and experience.

Temporal Distortion: (BASI) A temporal distortion is a temporary, false perception of the apparent slowing of time. When an individual experiences a temporal distortion, time expands and events appear to happen in slow motion. This can occur automatically under conditions of acute stress, but it can also be artificially induced by certain drugs such as marijuana.

(AFP) A transient subjective experience of space or time compression or expansion relative to reality usually associated with a "fight or flight" response.

Terrain: (AFP) Conformation, texture, and type of Earth surface beneath the plane of flight.

Thermal Stresses: (BASI) Extremes of ambient temperature (cold or heat) may produce changes in body temperature causing either discomfort or decrements in task performance.

Threshold: (BASI) An inherent perceptual limitation that requires that stimuli be presented within a certain range of intensity and duration.

(AFP) An inherent perceptual limitation that requires that stimuli be presented within a certain range of intensity and duration to ensure perception by the individual.

> **Subthreshold** - (BASI) Stimuli are presented below a detectable range or duration and thus are not perceived.
>
> **Suprathreshold** - (BASI) Stimuli are presented above a detectable range or duration and thus are not perceived.
>
> **Transthreshold** - (BASI) Stimuli are presented within a detectable range and duration and thus are perceived.

Threshold, Sensory: See Threshold.

Total System Approach: (Stringer and Riley, 1985) Provides for comprehensive analysis of pilot error accident data by providing a model of task performance. Contains the following system elements: mission, aircraft characteristics, environment, pilot capacity, and cockpit interface.

Training: (BASI) Training is the acquisition of required skills, knowledge, and attitudes for satisfactory task performance. Allocation of this category can relate to such issues as insufficient training, inappropriate training, or negative transfer of training.

Training Program Inadequacy: (AFP) Training program deficiencies are considered to be a factor when a pilot was not trained or was judged inadequately trained to perform the mission element being attempted.

Transfer of Training: See Learning.

Under Motivation: See Motivation, Anomalies of.

Underconfidence: See Confidence.

Unintentional Activation: See Error, Technical.

Vertical Takeoff and Landing Aircraft: See VTOL.

Vertigo: (BASI) Vertigo is defined as illusory sensation of turning, but in aircrew jargon 'vertigo' is applied to any form of spatial disorientation, even when there is no illusory sensation of turning.

Vestibular Illusion: See Illusion, Vestibular.

Vicarious Learning: (AFP) Learning by observation in the absence of any structured effort to impart the knowledge gained or "reading between the lines."

Vigilance: (AFP) The active, assertive management of attentional resources in information seeking and making decisions.

Visual Approach Slope Indicator: See VASI.

Visual Illusion: See Illusion, Visual.

Wave: (Klein and Wegmann, 1980) Pattern of periodic variations.

Workload, Emotional: (Gerbert and Kemmler, 1985) Psychological stress factors such as responsibility pressure, risk taking, and "fear of failure."

Workload, Mental: (Gerbert and Kemmler, 1985) Quality and quantity of the incoming information constitute the "mental workload" of the operator.

Workload, Physical: (Gerbert and Kemmler, 1985) Physical factors such as the amount of acceleration forces, vibrations, noise, and other environmental stressors determine the "physical workload."

Zeitgeber: (Klein and Wegmann, 1980) External periodicity driving an endogenous biological rhythm to achieve a certain phase or period; also called time-give, synchronizer, entraining agent, cue, or clue.

APPENDIX 4

SCENARIOS FOR PILOTED SIMULATION
PILOT ERROR STUDY

LGA-BOS (La Guardia to Boston)

Filed for Clipper 542:
LGA direct MERIT direct ORW direct PVD V-151 INNDY direct BOS - Cruise altitude FL210

La Guardia ATIS
"La Guardia information Echo, XX47 observation. Estimated ceiling 3000 broken, visibility 3, haze. Temperature 59. Wind 290 at 9. Altimeter 29.92. ILS approach RW 22 in use. Landing RW 22, departures RW 31."

Initial route clearance issued before pushback:

"Clipper 542 cleared to Boston Logan Airport via LGA 1 Departure, turn right heading 360 radar vectors to Merit as filed. Maintain 5000, expect FL210 10 miles after departure. Contact New York Departure on 120.4. Squawk 4060."

"Taxi to RW 31"

After takeoff and reaching 400 to 500 ft, they begin turn to 360. Tower will tell them to contact Departure. **"Clipper 542, contact Departure."** They clean up aircraft and by 1000 ft call Departure.

"Clipper 542, New York Departure, radar contact. Maintain 5000, expect higher in 2 min."

About 10 nmi NE of LGA (113.1), **"Clipper 542, turn right heading 075 to intercept 055 radial of LGA, contact New York Departure on 126.8."**

Miniscenario No. 1- unfamiliar route, high CDU complexity, short lead time, distraction- ("Say Groundspeed"), no malfunction:

After calling on 126.8, **"Clipper 542, turn further right heading 085 and join V-99 to MERIT, as filed. Climb and maintain 17 000. For traffic, cross 20 NE of LGA at 13 000 and 250 kn."**

At about 15 000 ft and about LGA 26DME, **"Clipper 542, contact BOS Center on 134.0."**

"Clipper 542, BOS Center, roger."

Miniscenario No. 2- unfamiliar route, low CDU complexity, short lead time, no distraction, no malfunction:

At about LGA 31DME, **"Clipper 542, cleared direct DENNA direct ORW direct BOS. Climb and maintain FL210, for traffic cross DENNA at FL190."**

Boston Logan ATIS
"Boston Logan Information Foxtrot. XX50 observation. Measured ceiling 500 overcast, visibility 2, rain. Temperature 59. Wind 240 at 8. Altimeter 29.92. ILS DME approach RW 27 in use. Noise abatement procedures in effect. Landing RW 27, departing RW 22."

Prior to ORW (110.0), **"Clipper 542, contact BOS Center on 128.6."**

Miniscenario No. 3- unfamiliar route, low CDU complexity, short lead time, distraction (Master Caution), no malfunction:

At ORW, **"Clipper 542, cleared direct PVD direct ARCER. Descend to cross PVD at and maintain 11 000."**

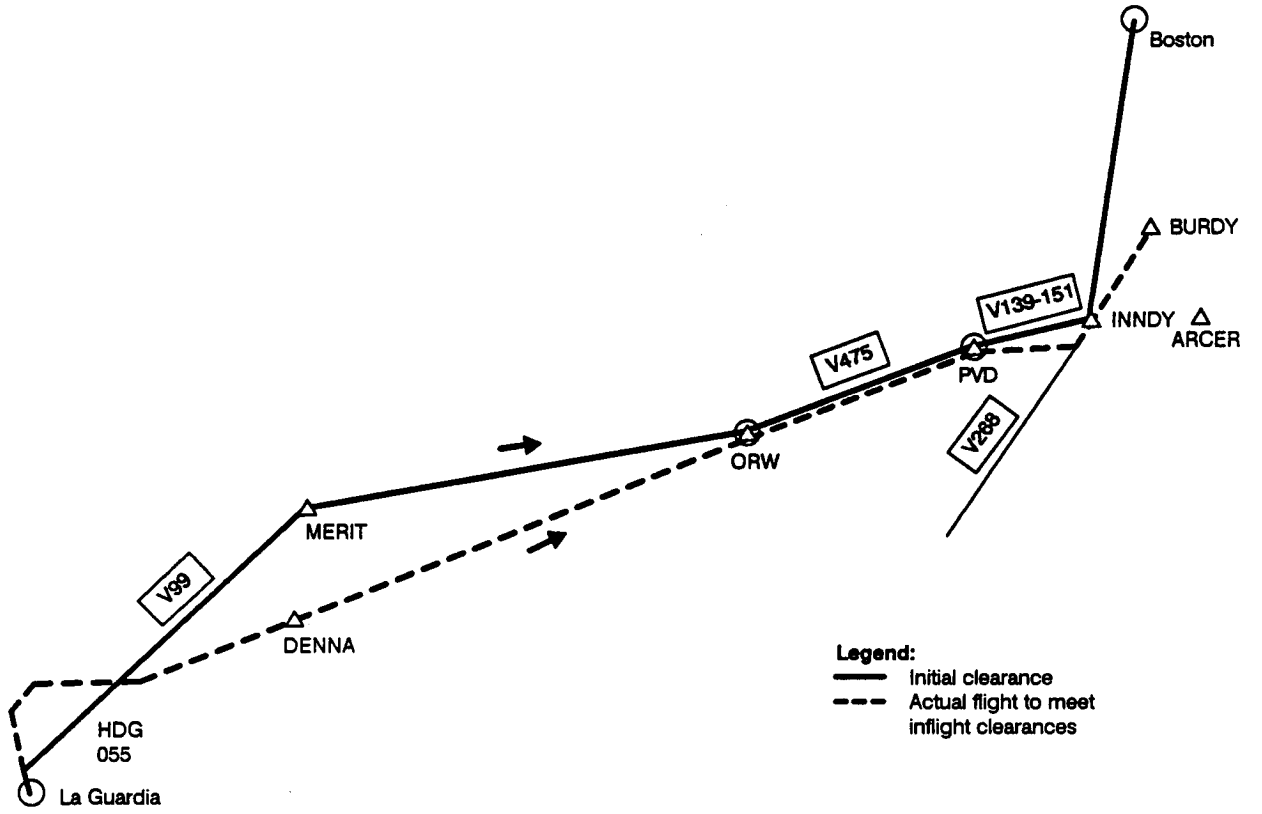
At PVD, **"Clipper 542, contact BOS Approach on 120.6."**

"Clipper 542, Information Foxtrot is current. Expect vectors for ILS DME RW 27 approach."

Miniscenario No. 4- unfamiliar route, high CDU complexity, short lead time, distraction (waypoint resolution), malfunction (A/P Disconnect):

About 7DME past PVD (115.6), BOS Appr: **"Clipper 542, due to traffic fly heading 100 to join V-268 to BURDY. Depart BURDY heading 070. Descend and maintain 4000, cross BURDY at 7000 and 190 kn."**

Two more vectors for sequencing, then cleared to 3000 on last vector of 290 to intercept final approach course. Intercept localizer on heading 290, about 15 nmi outside of LONER (25 nmi from RW).



La Guardia to Boston

9-U90183-16

BOS to LGA (Boston to La Guardia)

Filed route for Clipper 547:

BOS direct GLYDE V-292 BARNES direct HAARP direct LGA. Cruise altitude 16 000.

Boston Logan ATIS
"Boston Logan Information Golf. XX49 observation. Measured ceiling 900 broken, visibility 5. Temperature 59. Wind 240 at 8. Altimeter 29.92. ILS DME approach in use RW 27. Noise abatement procedures in effect. Landings RW 27. Departures RW 22."

Initial clearance for pushback:

"Clipper 547 cleared to the New York LGA airport via LOGAN SIX Departure to GLYDE, as filed. Maintain 5000, expect 16 000, 10 (min) after (departure). Contact BOS Departure on 127.2. Squawk 3502."

"Taxi to RW 22."

After reaching 400 feet after takeoff, begin left turn to 140 as per SID. **"Clipper 547, contact Departure."**

"Clipper 547, radar contact. Continue left turn to heading 120. Climb and maintain 5000. Expect clearance on course in 2 min."

About BOS 9DME (112.7), BOS Departure calls: **"Clipper 547, turn right heading 270."** (This will place plane over or near CELTS on heading 270.)

Miniscenario No. 1- unfamiliar route, low CDU complexity, long lead time, no distraction, malfunction (A/P Disconnect):

About 7 nmi past CELTS, **"Clipper 547, cleared direct MILIS. Do not exceed 250 kn, cross MILIS at and maintain 11 000. Depart MILIS heading 320 for enroute vector."**

About 1 min to MILIS, **"Clipper 547, contact BOS Departure on 128.7."**

Miniscenario No. 2- unfamiliar route, high CDU complexity, long lead time, distraction ("Request turbulence"), no malfunction:

Just before MILIS, **"Clipper 547, after MILIS fly heading 330 to join V-292 to BARNES, as filed. Cross 35 NW of BOS (112.7) at 15 000, climb and maintain 16 000."**

La Guardia ATIS
"La Guardia Information Hotel, XX50 observation. Measured ceiling 400 overcast, visibility 1. Rain. Temperature 59, dewpoint 55. Wind 180 at 10 gusting 15. ILS approach RW 22 in use. Landings RW 22, departures RW 31."

Prior to BARNES: **"Clipper 547, after BARNES, cleared direct IGN, direct HAARP, flight plan route. Contact BOS Center on 127.35."**

"Clipper 547, roger."

Nine miles before IGN (117.6), **"Clipper 547, contact New York Approach on 120.8."**

"Clipper 547, Information Hotel is current. Expect vectors for the ILS RW 22 approach."

Miniscenario No. 3- unfamiliar route, low CDU complexity, long lead time, distraction ("Squawk 4607"), no malfunction:

Six miles before IGN, **"Clipper 547, cleared direct VALRE, direct HAARP, flight plan route. Descend and maintain 8000, cross VALRE at or below 10 000."**

Few miles before VALRE, **"Clipper 547, contact approach on 134.9."**

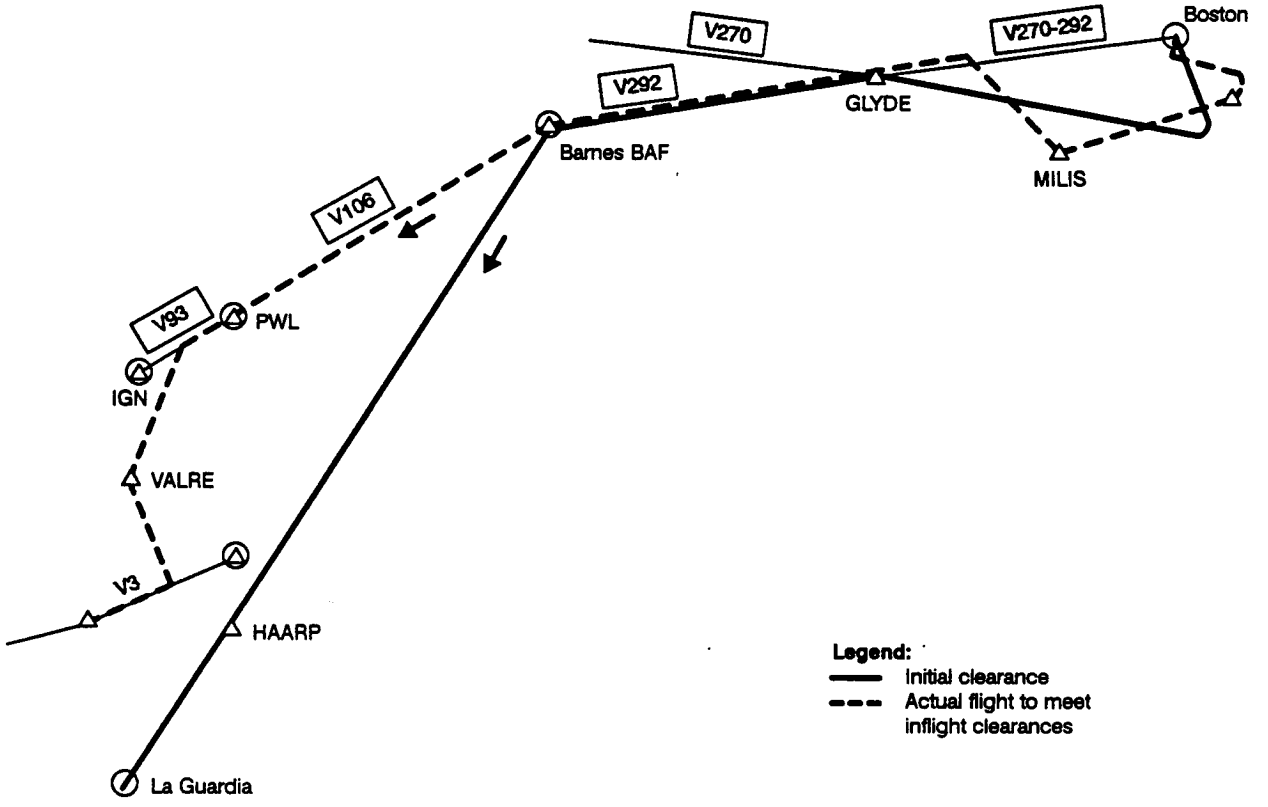
Just before VALRE, **"Clipper 547, after VALRE, fly heading 160, radar vectors to the ILS RW 22 approach at LGA."**

Miniscenario No. 4- unfamiliar route, high CDU complexity, short lead time, no distraction, no malfunction:

About 2 to 3 miles past VALRE, **"Clipper 547, RW 22 localizer just went down. RW 13 is now the active. Turn right heading 180 to intercept V-3 to NYACK. Cross NYACK at 5000 and 210 kn. Expect vectors to ILS DME 13."** (Don't forget to select new approach.)

At NYACK, **"Clipper 547, turn left heading 220, descend and maintain 3000, slow to 170 kn."**

"Clipper 547, 8 miles from GARDE, turn left heading 160, maintain 3000 until established on the localizer, cleared for ILS DME 13 approach."



Boston to La Guardia

9-U90183R1-15

KBFI-KMWH (Seattle to Moses Lake)

Filed for Alaska 123:
KBFI direct KMWH - Cruise altitude FL190

Boeing Field ATIS
"Boeing information Charlie, XX47 observation. Measured ceiling 600 overcast, visibility 1 1/2. Rain. Temperature 59, dewpoint 56. Wind 150 at 5. Altimeter 29.92. ILS approach RW 13R in use, landings and departures RW 13."

Initial route clearance issued before pushback:

(Assume 13R for departures)
"Alaska 123, cleared to the Grant County Airport via the Kent Two Departure, as filed. Maintain 5000, expect FL190 20 East. Contact Departure 119.2. Squawk 4601."

"Taxi to RW 13R"

After takeoff and reaching 400 to 500 ft, **"Alaska 123, contact Departure."** They clean up aircraft and by 1000 feet call departure.

"Alaska 123, Seattle Departure, radar contact. Maintain 5000, expect higher in 2 min."

Two min later, **"Alaska 123, expect enroute clearance in 2 min, climb and maintain 7000."**

Miniscenario No. 1- familiar route, low CDU complexity, long lead time, no distraction, malfunction (A/P Disconnect):

After reaching about 13 DME SEA (116.8), **"Alaska 123, proceed direct HUMPP direct MWH. Cross HUMPP at 11 000 and 250 kn, climb and maintain 13 000. Contact SEA Center on 120.3."**

"Alaska 123, Seattle Center, roger."

Miniscenario No. 2- familiar route, high CDU complexity, long lead time, distraction (Master Caution), no malfunction:

At HUMPP, **"Alaska 123, resume normal speed. Fly heading 060 to join V-2 to ELN direct MWH. Cross 29 west of ELN at and maintain 17 000."**

Miniscenario No. 3- familiar route, low CDU complexity, short lead time, distraction ("Say winds/temps aloft"), no malfunction:

Twenty-one miles before ELN (117.9), **"Alaska 123, for traffic proceed direct PERTT direct PELLY. Cross PERTT at and maintain FL190."**

Grant County ATIS
"Grant County Information Delta. XX49 observation. 800 scattered, measured ceiling 1400 broken.

Visibility 5. Temperature 59. Wind 300 at 10. Altimeter 29.92. ILS approach RW 32R in use, landing and departing RW 32R."

Prior to ELN, **"Alaska 123 contact SEA Center on 126.1"**

"Alaska 123, expect vectors for ILS RW 32R."

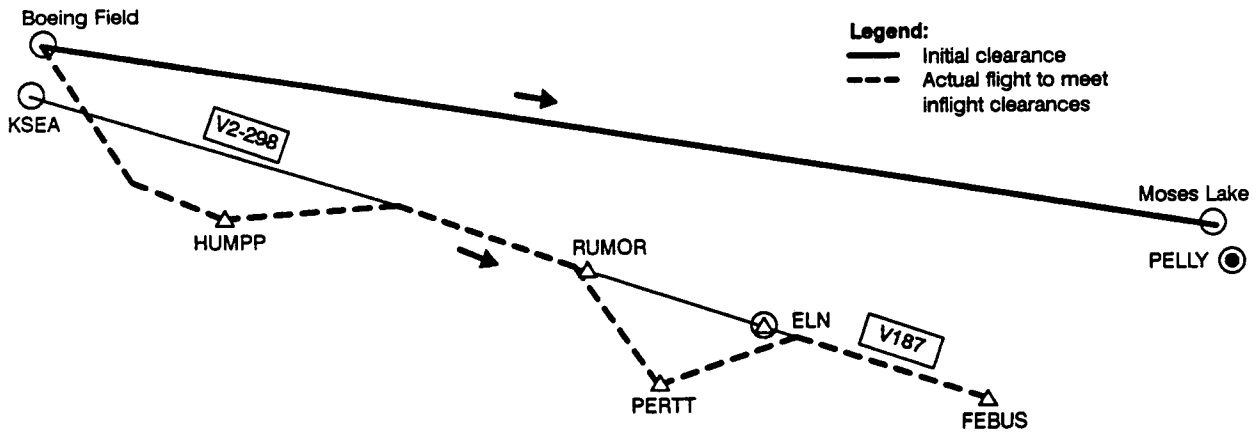
<u>Miniscenario No. 4- familiar route, high CDU complexity, short lead time, no distraction, no malfunction</u>

Five miles past PERTT, **"Alaska 123, revised route due to traffic. Fly heading 040 to join V-187 to FEBUS. Depart FEBUS heading 070. Descend and maintain 9000, cross FEBUS at 12 000 and 250 kn."**

At FEBUS, **"Alaska 123, turn left heading 070, vector to ILS RW 32R. Descend and maintain 6000."**

"Turn left heading 020. Descend and maintain 4000."

Two min later, **"Alaska 123, 6 miles from PELLY, turn left heading 350, maintain 4000 until established on the localizer, cleared for the ILS RW 32R approach."**



Seattle to Moses Lake

KMWH-KBFI (Moses Lake to Seattle)

Filed for Alaska 123:
KMWH direct KBFI - Cruise altitude FL180

Grant County ATIS
"Grant County Information Alpha. XX48 Observation. 2500 hundred scattered, estimated ceiling 4000 broken. Visibility 16. Temperature 59. Wind 300 at 7. Altimeter 29.92. Landing and departing runway 32R."

Initial route clearance:

"Alaska 123, cleared to Boeing Field via direct EPH direct. Climb and maintain 7000, expect higher in 5 min. Contact Departure 126.4. Squawk 3503."

"Taxi to RW 32R."

After takeoff and reaching 400 to 500 ft, **"Alaska 123, contact Departure."** They clean up aircraft and by 1000 ft call departure.

"Alaska 123, Grant County Departure. Report leaving 5000."

In a couple minutes, reach 5000 and call Departure. **"Alaska 123, contact Seattle Center on 126.1."**

Miniscenario No. 1- familiar route, high CDU complexity, short lead time, distraction ("Say Groundspeed"), no malfunction:

"Alaska 123, radar contact 4 SE of EPH (112.6). Revised routing. Fly heading 250 to join V-336 to ELN, direct BFI. Climb and maintain FL180, for traffic cross QUINT at 13 000."

Miniscenario No. 2- familiar route, low CDU complexity, short lead time, no distraction, no malfunction:

At QUINT, **"Alaska 123, cross 15 NE of ELN at 16 000, maintain FL180. Contact Seattle Center on 120.3."**

"Alaska 123, Seattle Center, roger."

Boeing Field ATIS
"Boeing Information Bravo, XX50 Observation. Measured ceiling 700 overcast, visibility 2. Light rain. Temperature 47, dew point 43. Wind 270 at 11. Altimeter 29.92. Localizer BC Approach RW 31L in use, landing and departing RW 31."

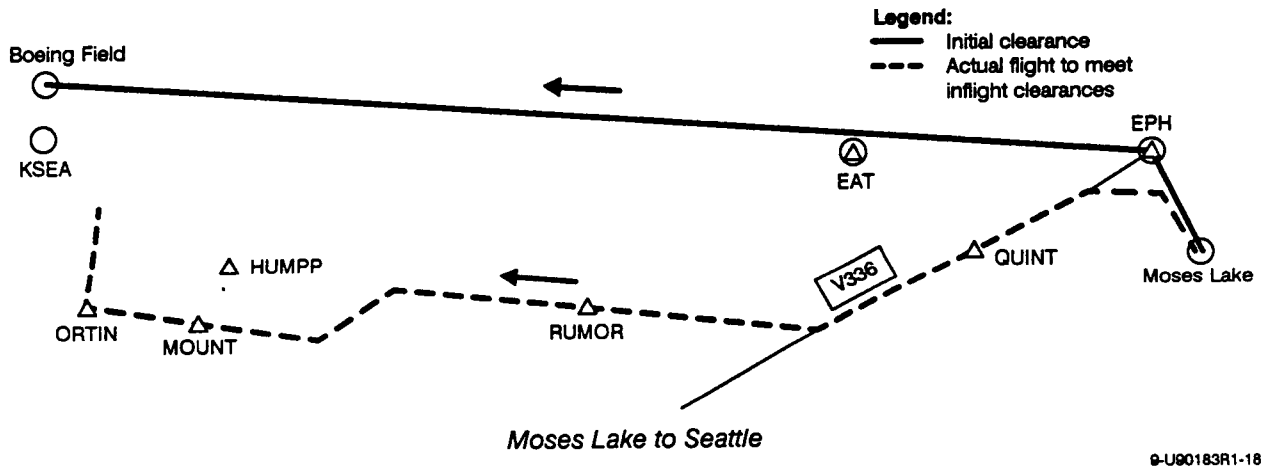
Miniscenario No. 3- familiar route, low CDU complexity, long lead time, distraction ("Squawk 3105"), no malfunction:

Ten miles before ELN (117.9), **"Alaska 123, cleared direct RUMOR direct HUMPP direct. Cross RUMOR at and maintain 14 000. Expect the Bense 3 Arrival, Ortin Transition."**

<u>Miniscenario No. 4- familiar route, high CDU complexity, short lead time, distraction ("Say Turbulence"), malfunction (A/P Disconnect):</u>

Eighteen miles to HUMPP (Halfway), **"Alaska 123, turn left heading 210 to join V-187 to ORTIN. Cleared to BFI via the BENSE 3 Arrival, ORTIN Transition. Cross ORTIN at 5000 ft and 190 kn. Contact Seattle Approach on 123.9."**

"Alaska 123, roger. After ORTIN fly heading 340, vectors for the Localizer BC RW 31L approach."



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Langley technical monitor: Cary R. Spitzer
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16. Abstract

Human error is a primary or contributing factor in about two-thirds of commercial aviation accidents worldwide. With the ultimate goal of reducing pilot error accidents, this contract effort is aimed at understanding the factors underlying error events and reducing the probability of certain types of errors by modifying underlying factors such as flight deck design and procedures.

A review of the literature relevant to error classification was conducted. Classification includes categorizing types of errors, the information processing mechanisms and factors underlying them, and identifying factor-mechanism-error relationships. The classification scheme developed by Jens Rasmussen was adopted because it provided a comprehensive yet basic error classification "shell" or structure that could easily accommodate addition of details on domain-specific factors. For our purposes, factors specific to the aviation environment were incorporated.

Hypotheses concerning the relationship of a small number of underlying factors, information processing mechanisms, and error types identified in the classification scheme were formulated. ASRS data were reviewed and a simulation experiment was performed to evaluate and quantify the hypotheses.

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